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THROUGH THE EYES OF THE EDITOR

Wilfred Hall Terrell does more than describe a technique for constructing dentures in his article; while it is not an analysis of various denture techniques, it does point out a means for variations from his basic technique. The basic technique is good, as it follows fundamentals. He points out the fact that there must be reasons for variations and that changes in any part of the technique may call for changes in other phases of technique. This fact is frequently ignored by clinicians, and it causes confusion in the minds of those who read or listen. The article describes the entire procedure which he uses in a manner which parallels his actual office practices. All phases of denture construction are described including mouth examination, patient relations, and the delivery of the dentures.

Joseph J. Jablonski has described a clever and accurate method for reproducing the position and arrangement of natural teeth on artificial dentures. The equipment and technique he has devised are simple enough to be practical. The relationships which can be maintained by the technique are important enough to be worth this addition to one's own procedures.

M. J. Robinson discusses centric position after accepting Thompson's definition of centric position. The claim is made that denture difficulties and temporomandibular joint disturbances may be caused by the mandible being in a forced retrusion. Two cases are reported to support these thoughts. The procedures used in making these corrections involve an increase of the vertical dimension. It causes us to wonder if the relief of the symptoms may have resulted from this change. May we point out that centric position is centric position. Any other relationship is an eccentric position, whether it be retruded or protruded. All dentures should be built in centric position. An "easy" centric or "functional" centric is not centric position.

Ralph H. Boos has described a new and interesting approach to the problem of registering the inclination of the condylar path on the articulator. This is done by means of roentgenograms of the temporomandibular joint. A technique for making the roentgenogram is described, as well as the equipment and procedure for the transfer of the records thus obtained. We wonder how much effect the variations in thickness of radiolucent tissues will affect the angulation. The suggested procedures should lead to research which could add greatly to the knowledge of the temporomandibular joint.

Frank H. McKevitt calls attention to the failure of the dental profession to apply the fund of information at hand regarding the fundamentals of anatomy, physiology, and occlusion. He feels that adhesive powders for dentures are being used excessively as a result of this failure. A means for measuring the vertical dimension is described, and other basic problems are discussed.

Samuel Friedman has described his understanding of an effective pattern of occlusion in dentures. He accepts the plan of a coordinated cusp occlusion and points out what he considers to be fallacies in other occlusal schemes. He emphasizes the importance of incisal guidance and condylar guidances. He describes a procedure for harmonizing the occlusion with the guiding factor. The great interest in this problem is emphasized by the

correspondence which follows. This also emphasizes the wide differences of opinion regarding it.

Miles R. Markley recommends the broken-stress principle in the design of fixed bridge prosthesis. The desire for conservative abutment preparations for bridges would seem to make this desirable. He describes several types of stress breakers which appear to be efficient.

R. M. Appleman has indicated the need for more adequate prosthetic treatment of patients who have lost parts of the maxilla as the result of surgery. The radical treatment of malignancies about the mouth which is used today requires the cooperation of the dentist and the surgeon. The simple classification suggested in this article should be helpful to the dentist who makes these restorations. The technique suggested for each class is sound and is worthy of study.

Abraham H. Lazarus emphasizes the importance of centric relation to partial denture design. There should be no quarrel with this, but too often the occlusion of remaining teeth is used as a guide for the occlusion of partial dentures rather than actual jaw relations.

E. J. Dinger and Floyd A. Peyton have conducted extensive research into the causes of distortion of gold partial denture castings. Their studies are very timely and should be of assistance to those who make castings. The procedure involved the testing and examination of many student castings made with varying procedures. The changes in form during heat treatment are particularly interesting.

Julius C. Sexson and Ralph W. Phillips have reported the results of research on the effects of abrasives on acrylic resins. Patients wish to know how to clean their dentures. We now have scientific background for our advice to them. The various tests seem to be carefully devised and carried out. Accurate measurements were made within the limits of experimental error from which concise tables of abrasive action were compiled.

Carl O. Boucher made an effort to give an honest appraisal of the impression techniques and materials in use for impressions. It is hoped that the reader will decide for himself which is best.

Carl O. Boucher

A PRECISION TECHNIQUE THAT PRODUCES DENTURES THAT FIT AND FUNCTION

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THIS paper is not an analysis of various methods of denture construction, but is a presentation of a particular technique given in as much detail as space will allow. Though you have your own method of construction, it is always interesting to see how someone else does it, and I hope there may be a few points given which you can at least add to your own procedures to advantage. There are many good techniques.

There has been a gradual progress in the development of materials and instruments available for denture construction, and also an increased understanding of the important factors necessary for consistent results. Exchange of ideas does much to stimulate progress. The dentures we make today should be better than those we made even five years ago. Let us see to it that progress never stops and that we never allow ourselves to reach the point where we feel there is no room for improvement and that we can learn nothing more. Thus, science, medicine, and dentistry will continue to progress rapidly. It is important that we all have some definite procedure for denture construction which we know will produce results that are excellent and follow it consistently. Short cuts in construction are usually very expensive, for too much time will be used later in adjustments. The ideal denture is one which fits the patient comfortably with a maximum of retention. It should have perfect balance, with teeth that are sharp enough to cut food. There should be coordination of function with esthetics, with sufficient study given to each case to produce a natural effect that is not detectable as being artificial. The accuracy of our work will show up in the limited number of adjustments which will be required. This means more return per hour and better satisfied patients. Satisfied patients are our practice builders.

FIRST APPOINTMENT

Examination

This appointment is a most important one, for it is at this time that we decide whether or not we want the patient, and the patient is deciding whether or not we are to be his or her prosthodontist. First, a thorough examination of the mouth is made to determine the favorable and unfavorable factors of the case. These should be noted and brought to the patient's attention. This should be followed by a consultation with the patient in order to ascertain a complete case history. From this we will

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learn much. We will learn why previous work has not been satisfactory and whether it was the dentist's fault, the patient's fault, or the fault of the mouth. We should be studying our patients during this consultation and decide whether or not we want them. It is much easier to get undesirable patients than it is to get rid of them. To be a successful prosthodontist we must choose our patients and take only those we are convinced we can satisfy. This does not mean to take only the easy ones. There is a satisfaction that is much greater than average in satisfying difficult patients. However, all patients must be analysed. Some are seeking the impossible and they are doomed to disappointment if they cannot be educated to their limitation. Prosthodontists are not miracle men. It is well to list on the patient's charts the favorable and unfavorable factors. These should be discussed with the patients, and no impossible promises should be made. We should call to the patients' attention the difficulties of their cases, and impress upon them their limitations.

After this discussion and examination we should decide upon the fee we will require to do the work. This necessarily must vary with all cases, and no fees can be set which will be fair to us or the patients until this appointment has been completed. If we accept the neurotic type we should make him pay for the grief he will give us. The secret of success in prosthetics, aside from the ability of the operator, is a thorough analysis of patients.

It is impossible to have a fixed fee for denture service that is fair. This must be determined for each individual patient. We should have a minimum and a maximum fee and determine what we must have for each case after a thorough study of all factors. We should not overlook the psychologic factor, for this is probably the cause of far more failures than the inability to build a good set of dentures. If the fee is accepted, it is better to require half down when the work is started and the balance on completion. If our patients have an investment in what we are doing they will be much more cooperative, since dentures that are paid for are always more satisfactory. Time payment is not very satisfactory in handling denture patients. Let them save up the money in advance if they want us to do the work. We then make a weekly schedule of appointments and we try, where possible, if the patients so desire, to give them appointments at the same hour on the same days of each week.

SECOND APPOINTMENT

Primary Impression

The subject of impressions requires more detailed discussion than some other parts of the technique, though it is only one link in the chain and no more important to success than any others.

There is considerable confusion in the minds of many dentists as to what is the best impression procedure. There have always been two schools of thought, one believing in compression, if this is possible, and the other in making impressions with the tissues at rest. Examples are the so-called mucostatic methods, or methods involving compression of tissue. Mucostatics is not new, for there have been

many impression methods used by our preceptors which involved this same principle of making impressions of the tissues in a static or at rest condition. I cannot agree, however, with the followers of the mucostatic technique, that peripheral borders should be arbitrary in extension and knife-edge in thickness. Neither do I agree that metal bases are always indicated. I make both acrylic and metal bases, and I think each has its place. There is no remedy that will cure all ills, and metal bases are not always desirable. Neither is one particular metal only the answer where metal is indicated. Furthermore, mucostatics is not a guarantee of a successful denture. Many other factors must enter in. I do agree with the mucostatic principle of making an impression, providing it covers all the available stress-bearing area and has a peripheral border which has been formed by the tissues.

Several years ago we found that in the cases we rebased we had practically no adjustments to make, the dentures were more comfortable, the retention was better and seemingly more permanent. We were taking these impressions with the tissues at rest, and there was no attempted compression which would give us distortion or displacement. Now, all our impressions are taken in this manner, and the results speak for themselves.

The primary impressions can be made with various materials and trays. The material selected should be quite soft so as not to distort the tissues, but should have enough resistance to carry it slightly beyond the denture base area and get a good impression of all the peripheral areas. We should use a material that we can handle well, and only one insertion of the tray should be required. It is important that the proper tray be selected as to size and shape before this impression is made. Throughout this technique a choice of materials and equipment will be given, as it is more important how you use them than which one you use. I will mention the materials which I use, but this does not mean that you cannot use others and get good results. The physical properties of any other materials used should be similar to these.

The materials that can be used for primary impressions are: (1) Muco-Seal, (2) alginates, (3) hydrocolloid, and (4) impression compound. Our primary impressions are taken with Muco-Seal in plastic trays which we made in the laboratory (Fig. 1). They are anatomic trays which cover the lateral throat form, the retromolar pad, and curve outward and up to get the external oblique ridges without cutting through the impression material. Alginates or hydrocolloids may be used in these trays, as they have rim lock borders for retaining the impression material. These trays can be made by reshaping and adding wax to standard S. S. White aluminum trays to be used as patterns. It is important to have a tray that will carry the material to the desired areas.

Muco-Seal is an acrylic resin which comes as a powder and liquid. When mixed, it is used in a very moldable or plastic form. It does not compress tissues, but it does get a beautiful impression of all denture base areas, and will spring out of the undercuts (Figs. 2 and 3). The detail is picked up in the final impression. Alginates or hydrocolloids may also be used. It is necessary to be careful that they flow up around the tuberosities, and that they do not trap air in vital spots along

the borders. Compound may be used if undercuts are not severe, and if it is softened sufficiently. Good primary impressions are just as important to the final results as good final impressions.

At this same appointment, the molds and shades of teeth are selected. The plan for natural effects is made by mixing shades and molds, if desirable, and deciding upon a characteristic setup for the type of individual. The advisability of art work to be done on the porcelain teeth with stains and glazes should be studied and outlined. All of these may be varied as the case progresses, for esthetics is a very important part of denture work and one that is often neglected.

OUTLINING BASES ON CASTS

The upper cast is outlined just to the point where the check begins to reflect. If overextended, the final impression will be cut through to the tray in places along the border, and this will have to be corrected before the final impression is made.

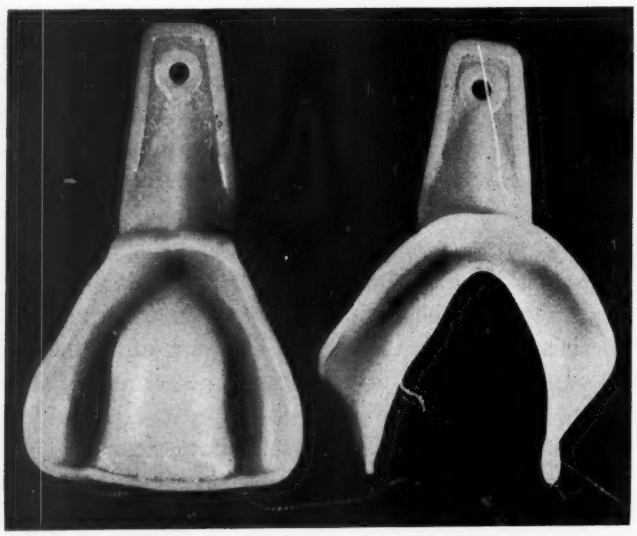

Fig. 1.—Primary trays made of plastic.

The lower must be very carefully outlined, not to be overextended on the border, and yet to cover all areas necessary for retention. The best final impression cannot be made by this method, if the base is not correct. Beginning at the distobuccal extremity, we follow forward on the external oblique ridge. This fades into the lateral surface of the mandible in the bicuspid region. As on the upper, the outline must follow close to the vertical surface of the mandible, the line where the reflection outward begins. Care must be taken to clear the attachment of the buccal and labial frenula. On the lingual, beginning at the distal, the outline crosses the distal of the retromolar pad and extends around in the arc of a small circle to the point where this intersects the distal end of the mylohyoid ridge (Fig. 4). There is no attempt made to utilize all the apparent area available here.

The outline then extends down the mylohyoid ridge, extending not more than 2 mm. over it. This is the rule, but the exception will allow in some cases for the extension to go to the floor of the mouth. These cases are those where there are no undercuts beneath the mylohyoid ridges, and the mouth is shallow. The primary impression from which the lower cast was made gave an impression of

Fig. 2.—Primary upper impression.

Fig. 3.—Primary lower impression.

the floor of the mouth at rest, covering that area which extends from the lowest point, which is in the bicuspid regions forward to the lingual frenum at the midline. This space is utilized for retention, adding much to the comfort and utility of the lower denture. The lower denture should be made thicker in this area (Fig. 5).

A great deal of care must be taken with the impressions and the outlining of the cases, or all value will be lost. There are two places to watch closely. One is the two papillae forming the opening for the sublingual glands; the other is the lingual frenum. These are the only places that are likely to develop soreness, and this can be very severe if not observed in time. All outlines on upper and lower casts are scratched with a sharp instrument so the technician can see where to trim the borders of the acrylic bases.

ACRYLIC BASES

The acrylic bases not only serve as our impression trays, but also are used for obtaining: (1) vertical opening, (2) approximate centric, (3) check bites to obtain the maxillomandibular relationship, and (4) bases on which to set up the teeth and try them in. They are waxed up on the casts with a full thickness of baseplate wax and then reinforced around the border and across the distal and

Fig. 4.—Lateral inside view of a typical lower denture made by the Terrell precision technique.

Fig. 5.—Lingual view of a typical lower denture.

slightly to the lingual of the ridges (Fig. 6). They should be rigid when completed. They are made of denture acrylic and cured in the same manner. It is not necessary to give them a long slow cure as there is no bulk of material, and they are only for temporary use. They may also be made of the self-curing tray acrylic in about thirty minutes. After curing, the bases should be trimmed to the bead which has resulted from scratching the cast along the line which was drawn to determine the border outline. Wax rims are added, and they are then ready for the next appointment.

THIRD APPOINTMENT

Vertical Opening and Final Impressions

Vertical opening is not determined by any rule, but by judgment of the operator. Currently, there is much said about freeway space and the rest position of the mandible. The space between the wax rims, when the patient is speaking,

should be approximately 2 millimeters. It is well to observe the patient during speech, and if the wax rims should contact on certain words, they should be reduced in height. If the space should be more than 2 mm., the rims should be lengthened.

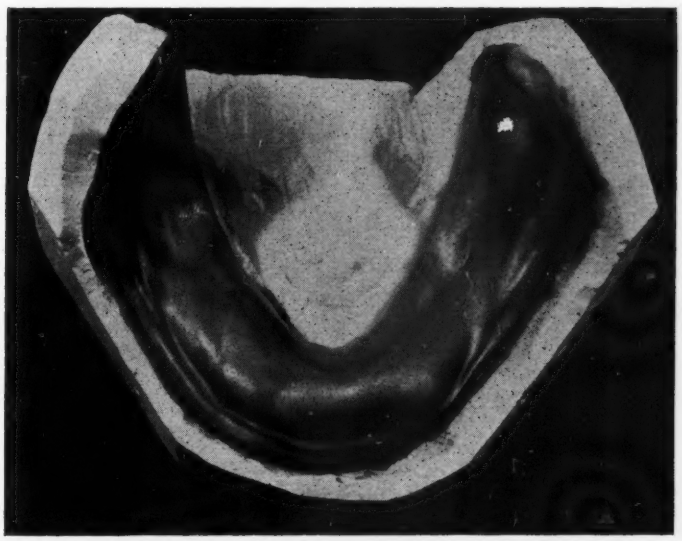

Fig. 6.—Wax-up for the plastic impression base.

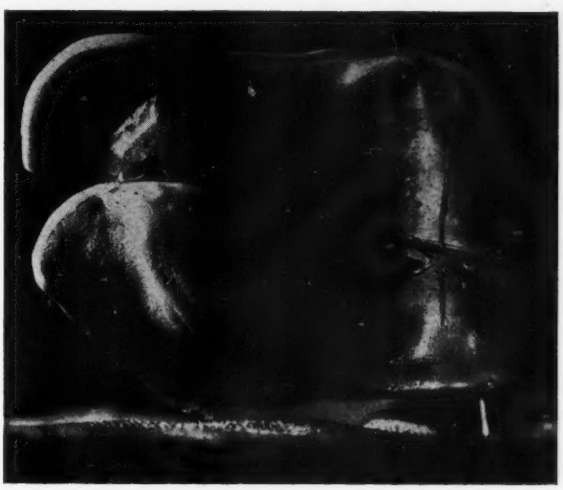

Fig. 7.—Wax bite blocks for obtaining the vertical opening and approximate centric relation.

Have the patient count from one to ten, first slowly, and then rapidly, and observe the space between the wax rims. The esthetics of the case when the patient has the rims in contact is an aid, but it should be remembered that there should be this freeway space allowed when the mouth is in repose. To build the wax rims so they contact at the desired esthetic vertical opening would be giving the patient

too great a vertical opening (Fig. 7). The length of the teeth for esthetics can be varied by the overjet and the overbite, but correct vertical opening has to do with comfort when the mouth is in repose, during speech, and when the dentures are in function. If the dentures are firmly in place, the teeth should never contact at any time during speech. Some attempts have been made to determine vertical opening by finding that point at which the patient can produce the greatest amount of biting pressure. There are other methods which attempt to establish the opening by dividing the face into thirds, establishing the lower third of the face equal to each of the other thirds. This, in some cases, will work, but in many patients these proportions would not be correct. From an esthetic standpoint we cannot make our patients all fit a rule. By establishing a freeway space between the wax rims

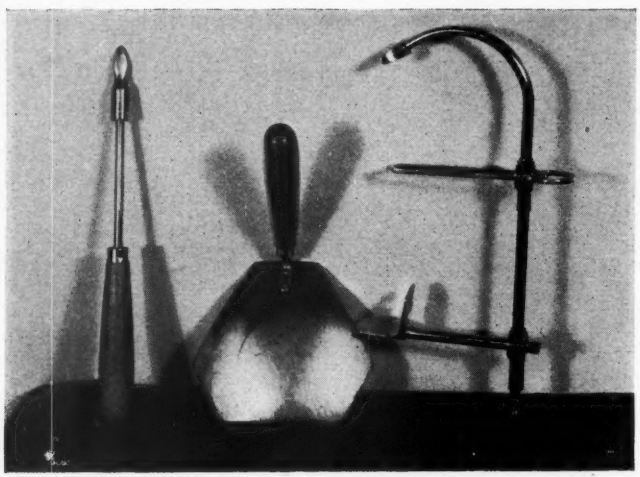

Fig. 8.—Instruments used for obtaining vertical opening. Curved hot plate and wax pooling instrument designed by Dr. M. M. House. Sorenson bite gauge used for comparative measurements in obtaining the vertical opening.

and observing the patient for a considerable time during speech, we can come very close to determining a vertical opening which will not only be comfortable but also incorporate the esthetic requirements. The wax rims are reduced by means of a *curved hot plate* (Fig. 8) until they contact at the desired height. This vertical opening which has been carefully established will be carried through to the finished case by means of the articulator used. It must have an incisal pin or a definite vertical stop in order to preserve this opening.

The method used to obtain centric closure is to tilt the chair horizontally with the head well back. First, the patient is instructed to move the mandible forward and backward until a slight thud is felt or heard as the condyles hit the back of the glenoid fossae. This is practiced with the wax rims slightly separated as the mandible is moved forward and backward.

After notching the upper rim and pooling the lower wax rim with a *hot pooling instrument,* the bases are placed in the patient's mouth and the mandible moved forward and backward as before. By pressing very lightly on the tip of the chin you can feel the condyles reach the back of the glenoid fossae. Stop the patient

at this point, instructing him to roll the tongue as far back in the roof of the mouth as possible and gently close. The soft wax in the center of the lower rim will key itself to the notches in the upper (Fig. 9), but do not let the patient decrease the

Fig. 9.—Wax rims keyed together in approximate centric relation.

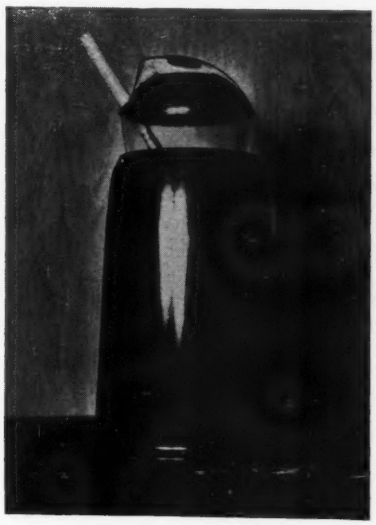

Fig. 10.—Heater for impression gel.

vertical opening by applying pressure to the rims. When cooled, have the patient close with a slight tapping motion, and it will be noted that closure is always at the same point. At this time it is well to mark the median line on the wax rims before they are removed.

THE UPPER IMPRESSION

The upper impression is made by painting the tissue surface of the impression base with the material selected for the impression. There are several materials which could be used as long as they have the essential physical properties. We

become familiar with the use of certain materials, and when we change to another it is often difficult to get a good result until we have had considerable practice with it. The material which we select for this purpose should be one which will flow readily in the mouth, one which will not distort or displace tissues, and one which will accurately copy the surface detail of the tissues. Selection of the material should be determined by the accuracy with which it reproduces the surface anatomy of the tissues combined with the ease with which it can be used by the operator. Most of the zinc oxide eugenol impression pastes will serve this purpose very well, though they are somewhat difficult to use. The material I am using at present is one which flows very readily. It is called Indicator Gel (Fig. 10). It softens when heated, and when it is chilled becomes quite firm. It will not stick or adhere to the tissues and can be removed easily from the base if the first insertion is not satisfactory. It is also possible to surface heat it with a spot heating torch or add to it. We use it not only for the final impressions, but also for relining and rebasing and for locating pressure spots under dentures. It is not foolproof, and requires some skill in its use, but the results will justify the care required.

Fig. 11.—Final upper and lower impressions.

This material is brushed on the inside of the acrylic impression base. A spot heating torch or jet of steam is then used to smooth the surface and eliminate bubbles. The impression is guided lightly to place, and the patient is instructed to open the mouth wide while the impression is steadied by the operator. All the muscle trimming that is done around the upper is just a gentle inward and downward pressure against the tissues of the cheeks and lips so that the borders are not thickened and the border tissues are not displaced. It is then chilled before removal (Fig. 11). It is easy to correct any point which may have failed to obtain a good impression by heating it and then adding a little of the impression material. This is again heated and placed in the mouth.

We have added a third step to our impression technique which completely eliminates the old trial-and-error method of building peripheral borders which has been used for so many years. With compound, no two impressions of the same mouth would be identical on the peripheral borders, but by this method of obtaining the peripheral border, a number of impressions of the same mouth will

be the same. The final impression of the peripheral border is obtained by the use of Truplastic, soluble plaster or impression plaster. For the best retention of upper dentures, we must have perfect tissue adaptation. In addition to this, we must have an accurate peripheral border and a good seal across the posterior. This sounds obvious, but a careful analysis of dentures with which patients are reporting difficulty with retention will show that it is a failure in one of these three points. To have maximum retention, the peripheral border should include all of the space in the buccal and labial reflections, from tuberosity around to tuberosity. However, it must not be thick enough to interfere with muscle function. Dentures which require very little adjustment do not just happen, but are the result of a careful, accurate impression technique, coupled with a balanced occlusion.

Fig. 12.—Skull showing the Hamular notch.

The chair is now tilted horizontally with the head well back, and the impression is made of the periphery by applying a very small amount of the special impression plaster around the peripheral border by means of a cement spatula. Place wet cotton rolls between the wax rims and have the patient close firmly. The cheek is held out, and the Truplastic is placed high up in the buccal fold around the tuberosity area, coming forward to the cuspid area, across the anterior, and back to the tuberosity area on the opposite side. The chair is next placed in an upright position. The patient is instructed to bring the lips together firmly moving them forward and backward. With the patient relaxed, the thickness of the peripheral border is molded by gently pressing inward and downward. The border should be so perfectly molded that it will not be necessary to trim the finished denture. The post damming is not done on the impression, but always on the cast. If the impression of these tissues has been taken with them at rest, we can apply our seal across the posterior border by grooving the cast the desired depth,

and we can control exactly the pressure to be applied. In order to have a good post dam, it is not necessary to compress this tissue to a maximum as is often done by the post damming techniques employing modeling compound. After the upper denture impression is completed we mark the hamular notches (Fig. 12) with an indelible pencil and connect these with a line which usually passes through the palatal foveae. We observe, by having the patient say "ah" and thus flexing the soft palate, just where the post dam should be placed. The compressibility of

Fig. 13.—Upper casts showing the post dam and palatal seal.

Fig. 14.—Palatal view of a skull.

this tissue is then tested. The post dam should always be placed on the immovable compressible soft palate, but should not extend distally on to the flexible soft palate. A post dam accurately placed and carefully done should never require adjustments. Besides the post dam, we have added an additional seal which we term a palatal seal (Fig. 13). This has been used for several years now, giving considerable additional retention to the upper denture and with no detrimental effects. It extends forward, on either side from the posterior palatine area, in that soft tissue between the hard palate and the base of the ridge (Fig. 14). This tissue

should be palpated with a large ball burnisher, and a line drawn with an indelible pencil along the area of greatest compressibility, stopping when it reaches the noncompressible tissue in the rugae area. This will add much to the retention of the upper denture. After having marked the post dam and palatal seal, we replace the upper impression, getting a transfer of the lines on the impression. With a sharp pointed instrument we scratch a line along the mark so that it will be transferred to the final cast that we may know exactly where these seals are to be placed. The depth of the seal which is placed on the cast with a No. 8 round bur should be between one-fourth and one-half the diameter of the bur. If it should be too deep it could be polished off in the finished denture, but a little practice will show the amount the average mouth will require. If done properly, there will be no soreness on the post dam or the palatal seal, and the retention will be greater than any you have ever known without the addition of this step (Fig. 15).

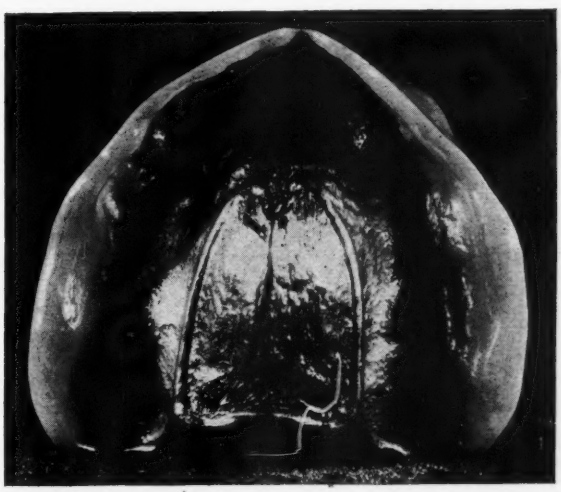

Fig. 15.—Palatal view of gold upper denture.

Retention obtained in this way will remain much more permanent than retention obtained by increasing the pressure around the peripheral border. Soft flexible tissues do not change by the addition of slight pressure, but hard tissues will soon resorb and cause a loss of retention. Remember to place the seals in the correct places by transferring these lines from the mouth to the impression, and not arbitrarily placing them on the cast with no guide to follow.

THE LOWER IMPRESSION

The technique for the lower impression is exactly the same as for the upper. The inside of the impression base is coated with a thin coating of the impression material. It is seated in the mouth without pressure and held by the operator with the mouth open wide while the material sets or chills. Upon removal, if the impression is satisfactory, we are then ready to apply the peripheral border in the same manner we did in the upper impression. If there are any places that need correction this should be done first. The difference between the lower impression

and the upper is that the tongue is on the lingual border of the lower, and a certain amount of movement must be allowed for. While making the lower impression, we instruct the patient to raise the tongue and move it around as if to clear the buccal and labial spaces of food. We limit the movements of the tongue to this amount, and it is not necessary for the patient to extend the tongue out of the mouth or move it to the extremes. If we allow the full range of movement of the tongue, we will lose the lingual-peripheral adaptation (Fig. 16), and a great deal of our chance for retention on the lower denture will be lost. The reason the patient is instructed to hold the mouth open wide while the impression sets is so that the muscle pull of opening the mouth to the extreme will not dislodge the finished lower denture. When this part of the denture is satisfactory the impression is completed the same as the upper, by first having the patient close on wet cotton rolls and then placing a very small amount of the special impression plaster around the peripheral border to complete the bucco-labial-peripheral seal. We then apply

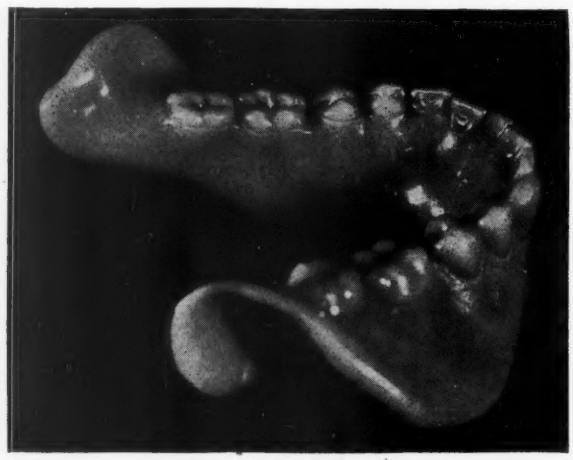

Fig. 16.—Lateral occlusal view of a typical lower denture.

inward and upward pressure on the cheeks and lower lips to mold the excess material away so there is no overextension. The peripheral borders as finished in this manner will be the exact contour of the peripheral borders of the finished dentures. The impressions are then removed and the casts poured. It is not necessary to box the impressions, though there certainly is no objection to doing this. With an indelible pencil, mark a line around the entire peripheral border of both upper and lower impressions, about one-fourth inch down on the outside of the impressions. This gives a line to which the stone is trimmed, just before it sets, so the thickness of the entire peripheral border will be reproduced. A good mix of cast stone is important. Thoroughly mix the stone according to directions, and then place it under vacuum to remove the air from the mix. It is then taken out of the machine, placed in a towel, and some of the moisture absorbed. It is important to have a good vibrator so this stone, which is quite stiff in consistency, can be vibrated carefully into the impression. If metal split cast plates

are used, the cast half of the plates is placed on the bench, and stone is built up on it (Fig. 17). The impression is then inverted on this stone and gently vibrated down to make the base of the cast as thin as possible. The stone is then molded up around the outside of the impression so that it covers the indelible line. Just before the stone has set, the excess around the peripheral border is cut back to the indelible line. This serves the same purpose as boxing the impression, if it is carefully done. But, in order to do it this way, the stone must not be thin. We pour our casts on some squares of plastic, and as soon as the stone begins to set, they are placed under water until the stone is set. This is the same principle that is used when a cement sidewalk is kept wet while the cement is setting. The special impression plaster or Truplastic which is used to take the impressions of the peripheral borders should be painted with a coat of sodium silicate, or water glass, before the cast is poured. This will facilitate separation

Fig. 17.—Split cast remounting plates which were designed by the author. These make accurate remounting of the cases after curing.

and will keep the plaster from absorbing moisture from the stone around the periphery, in the initial set. If metal split cast plates have not been used, the bases of the casts should be grooved before mounting them on the articulator. This permits the casts to be removed from the articulator, and again replaced after the dentures are cured. This makes it possible to correct any changes that occur between the time when the cases are flasked, and the time when they are removed from the flasks. When the cases are remounted on the articulator, it will usually be found that the bite is open from one-half to one millimeter. By use of the injection method, or by use of spring clamps, this change can be kept to a minimum, and a few will come out demonstrating practically no change. A small amount of opening does no harm; in fact, it is an advantage as it allows us to do the occlusal correcting and milling, and still complete the case at the original vertical opening.

FOURTH APPOINTMENT

Recording Maxillomandibular Relationships

Many otherwise good cases have been ruined because of an incorrect centric relation. There are many methods of recording centric jaw relation. Before check-bites can be taken, the casts should be mounted on the articulator that is to be used. They are mounted in an approximate centric relation by means of the wax rims. The impressions should not be removed from the casts until this step has been completed. Be sure that the incisal pin of the articulator is set when they are mounted, so the vertical opening will be preserved (Fig. 18). The impressions are then removed from the casts, and bases are cleaned up, and the wax rims are

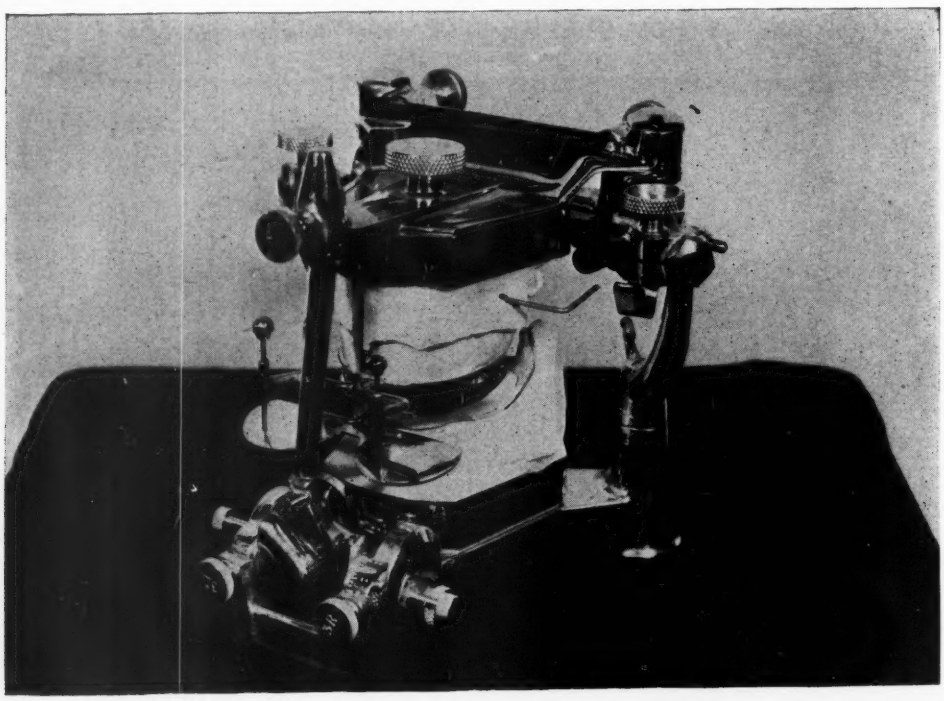

Fig. 18.—Relationship recorder mounted at the previously determined vertical opening.

removed. All undercuts on the casts should be blocked out with wax, and these undercuts removed from the plastic bases. The casts are then tinfoiled, and the impression bases are coated with zinc oxide eugenol paste, and seated to place on the tinfoiled casts. This gives an exact reproduction of the tissues as they were recorded by the final impressions (Fig. 19).

The relationship which should be recorded depends upon the articulating instrument which is to be used for the case. The more fully adjustable the instrument, the more valuable complete records will be. If your instrument has no condylar adjustments, then the important thing to record is an accurate centric relation at the required vertical opening. Other check bites or records would be of no value and a waste of time. If your articulator has condylar adjustments, such as the Hanau articulator and others of this type, it is important

to take records of centric and protrusive positions. If you are using a fully adjustable articulator such as the Coordinator, the House, the Stansbery Tripod, or the Gysi Trubyte Articulator, then all four check bites, centric, protrusive, right and left lateral, should be taken, and will be of value. Three of the instruments just mentioned, have, beside condylar adjustments, a Gothic arch control which works against the incisal pin. Here lateral check bites are valuable, for the instrument can be set to follow the patient's lateral Gothic arch path. Before deciding which records to take, classify your instrument—nonadjustable, partially adjustable, or fully adjustable. With nonadjustable instruments, take centric records. With the partially adjustable instruments, take centric and protrusive records. With the fully adjustable instruments, take centric, protrusive, and right and left lateral records. It is possible to build good dentures by using any of the articulating instruments. The mouth can even be used as an articulator. The articulator does not determine the dentures, but it is the skill of the dentist and his adaptation of his

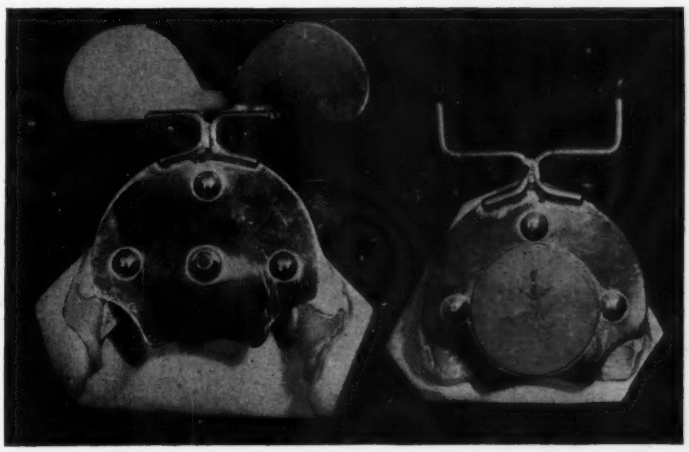

Fig. 19.—Relationship recorder designed by the author is used for taking plaster check bites.

knowledge in the construction of those dentures which is most important. The articulator is a valuable aid in the construction of dentures. The more fully adjustable the instrument is, the more is the refinement which can be put into the occlusion.

You probably all have read of at least two men who have discredited the use of articulators, and in my opinion their essays have contributed nothing to the advancement of prosthetic dentistry. In fact, I think they have done much harm. They can undoubtedly build dentures without an adjustable articulator, as I think most any of us can. But that is no reason to discredit the man who will work to finer detail and build more accuracy into his cases by properly using an adjustable articulating instrument. I have no doubt that they believe they are right, but that does not make all others wrong. There are many roads that lead to Rome, and many right ways of building dentures.

Though I do not consider it the best way to build dentures, some dentists prefer to use the mouth as an articulator. I will describe one way that this can be done.

Assuming that the casts have been mounted on a hinge with a vertical stop in correct centric relation (I would prefer a Gothic arch tracing with a plaster check bite to determine this), the teeth are set up on a flat plane. They are then tried in the mouth, and a wax check bite is taken in protrusive. This is examined to see whether the anterior teeth and posterior teeth are contacting at the same time. If only the incisors touch, the curve in the molar region is steepened and another wax check bite is taken. As long as the teeth do not contact in the posterior at the same time as they do in the anterior, it means that the occlusal curve is not steep enough to harmonize with the patient's condyle path. If there is three-point contact in all positions the dentures will be stabilized, but any set of dentures that does not have at least a three-point balance in all positions will continually be subjecting the base tissues to trauma. This will cause soreness, resorption of the

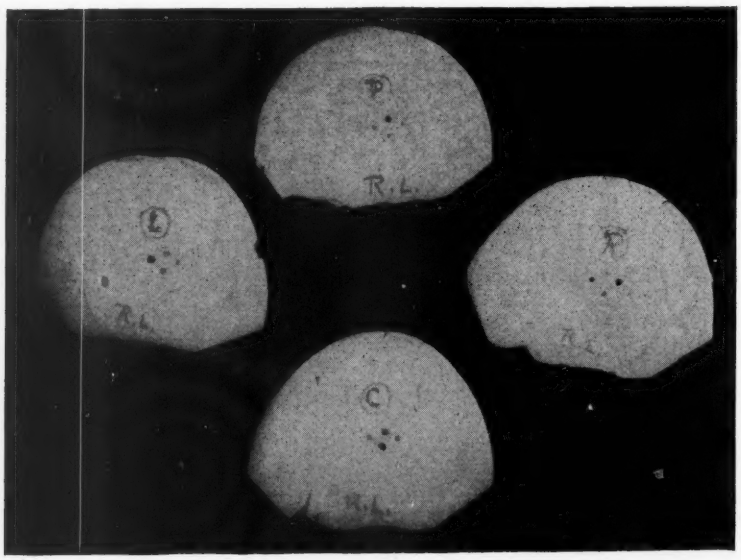

Fig. 20.—Plaster check bites used for setting the coordinator controls to reproduce the maxillomandibular relations.

ridges, and a gradual loosening of the dentures. If you can balance a set of dentures, you can use the mouth as an articulator, and the end result may be very good. For most men it is more difficult to get a good result by this method than to use an articulator which is at least adjustable to protrusive position. The teeth may be balanced accordingly on the instrument. While a partially adjustable articulator may not duplicate all details of movement, it does serve as a caliper to show us the steepness of the condyle paths, at least. It also indicates how we must set the teeth to coordinate them with the patient's jaw movements. The use of a fully adjustable instrument is, of course, a still greater aid, due to the fact that the teeth will articulate in the mouth, just as they do on the articulator if it has been properly set. This applies, however, only to the fully adjustable instruments. Regardless of what kind of an articulator is used, I prefer to use plaster check bites in combination with a central-bearing Gothic arch tracing, to secure centric relation,

and the other check bites, if they are required (Fig. 20). This eliminates all guess work in securing a balanced accurate centric relation, and it is a means of adjusting any articulator to the required relationships for that instrument. The more fully adjustable the articulator used, the less grinding will be required at the chair to correct the occlusion after the dentures are finished. It is a means of giving our patients dentures with a maximum of efficiency and comfort, providing good impressions have been taken. Fully adjustable articulators accurately reproduce the jaw relationship records. A check with articulating paper will reveal multiple cusp contacts in all positions both on the working and balancing side, and very seldom is it ever necessary to grind the occlusal surfaces of the posterior teeth when the dentures are placed in the patient's mouth.

Fig. 21.—The new T Mold posterior tooth. Note the possible multiple cusp contacts and the accentuated carvings which eliminate recarving after milling.

FIFTH APPOINTMENT

Setup Anterior Teeth

At this appointment the anterior teeth are set up for esthetics and phonetics. Here again there is no rule, but the results will lie with the judgment of the operator in cooperation with the ideas of the patient. If the esthetics of previous dentures has been good, this can be used as a base upon which to improve. Never be satisfied until the new dentures look much better than the previous ones. There is no such thing as perfection here, and all dentures could be improved. In fact, to most patients, esthetics means more than the details of balanced occlusion. Don't allow yourself to get the reputation for dentures that fit and function alone without coupling with this a reputation for making the most natural and best

looking teeth. One is just as important as the other. If you have no previous record of the patient to go by, it is important to have the patient look up any photographs which he may have, that were taken at any age when the permanent teeth were in place. By the use of a magnifying glass it is possible to determine the tooth form and arrangement from photographs which may have been taken many years before. Also, the use of advice from other members of the family is valuable in getting a setup which is satisfactory to the patient, and which looks to them as it should. After the anterior teeth are set to satisfaction, the posteriors are set up.

At this point, I would like to describe to you the new posterior teeth which I have recently carved (Fig. 21). They are known as the T Mold. I have no interest in this tooth, except that I think it is giving us something we never have had before in posterior teeth. I have been using this tooth for some time now, and find it is giving my patients better function than they have ever enjoyed with previous teeth. Since artificial teeth function on ridges covered with a sensitive membrane, it seems they should be made as sharp as possible. They have to chew food with approximately one-tenth the pressure that is exerted on natural teeth. Artificial teeth of all types, after adjustment for balance in the finished dentures, have poor excuses for cutting surfaces. We have tried to recarve these surfaces with stones and diamond points, but the result was rather crude and not very effective. The T Mold was carved and balanced on the Coordinator. The grooves have been deepened and sluice gates opened; the cusps have been sharpened and multiplied by the addition of supplemental grooves. After the wax teeth were cast in metal they were again mounted on the Coordinator and spot-ground and milled. These were then recarved and repolished. Several sets of teeth were carved in development before these final ones were perfected. The molds from which the teeth are being made are from these last metal teeth, and they are available in three sizes: large, medium, and small. The anatomy is so accentuated that spot grinding, if the teeth have been properly balanced, will not eliminate the cutting surfaces, and they require very little recarving after milling. They are slightly narrower buccolingually than natural teeth, thus lessening the pressure on the ridges. They are wider at the neck than most posterior teeth, thus eliminating food pockets, or the show of acrylic between the teeth. Best of all, they are easy to set up and balance, and they are efficient when finished.

SIXTH APPOINTMENT

Final Try-In

This appointment should be repeated as many times as necessary, but the patient should understand that the arrangement arrived at is final. A little extra time given for a try-in may save a lot of trouble later on. Two or three extra appointments, if necessary, are quite important. If desirable, other members of the family or particular friends may be invited to come in and give their advice. This will often do much toward the satisfaction of the patient. These critical friends or relatives can ruin a perfectly good set of dentures for us. How many

times have we all had this happen? I now ask them to bring their most severe critics, whether it is a member of their own family or one of their close friends, and I let them understand that it is possible at this time to make any changes whatsoever that they may desire, providing they do not violate any of the rules for balance and articulation of teeth. We can lengthen the teeth, or shorten the teeth, we can move them farther forward, we can move them farther back, we can set them straight, we can make them irregular, we can slant them out at the incisal edge, we can slant them in at the incisal edge, we can overlap them, space them, in fact, we can do anything they would like us to do, even to changing the molds and shades, but this is their last chance. These changes must be made while the teeth are still in wax. This is the only time we can do this, and after the dentures are cured they are finished. If the patients should change their minds after the dentures are finished, that is not our responsibility, and they should be told this. I sometimes set the teeth in hard wax, and allow the patients to take the trial dentures home. They are instructed to be careful to keep them chilled previous to trying them. They can then try them in at home and discuss them, and often times they are much happier after having done this. We do not go to these extremes with most patients, but occasionally it pays.

A prosthodontist must understand psychology in order to satisfy his denture patients. We must continually be watching our patients' mental reactions as the case progresses, and we cannot relax for one moment on this phase of the work. In most cases, I would say it is every bit as important as the technique we use. As Dr. House often says, "It is easier with some patients to fit the mouth than it is to fit their minds." His mental classification of patients has been very valuable to me. He classifies his patients into four groups, philosophical, exacting, hysterical, and indifferent, or a combination of these.

The philosophical type is the most valuable, and the one we enjoy the most. These people are intelligent; they understand what we are doing; they do not expect us to perform miracles; they are cooperative, and if we do our part, we can rest assured the case will be a success. Would that they were all the philosophical type.

The exacting type we can enjoy working for, if they have coupled with this a philosophical mind. It is a pleasure to work for exacting people, because they appreciate the fine detail that you put into their cases. However, there is in the exacting type the patient who carries a chip on his shoulder, and has very little confidence in anyone. The patients in this category are very difficult. They are often extremely intelligent and think they know everything, but they have some of the queerest ideas when it comes to dentures.

The hysterical type includes those patients who are usually shallow mentally. They do not want to be hurt; they get terribly upset over very insignificant things, and you never know where you stand with them. They may be fine one day but the next they will be "all off the beam." However, you eventually get their work completed.

The indifferent type of patient doesn't care what you do, or how it is done, and doesn't show much appreciation for anything you do after you've done it.

There is not much pleasure in working for the indifferent patient. Usually those in this group do not give too much trouble. We may have classified our patients at the first appointment, but by the time we have arrived at the final appointment, we know whether we were right or not.

This is the time to lay the foundation for the next appointment which will be the patient's first introduction to the new dentures. You know by now just what to expect, but this is your last chance. The next appointment, when they come in to get their dentures, should be one that is thrilling both to the patient and to the dentist. After all the hard work that has been put into the case, it is wonderful to have the patient pleased and happy. The determining factor of success is whether we have produced dentures that satisfy the requirements that are expected. During these earlier appointments is the time to educate the patient as to what to expect, and to the limitations of his particular case. If during this time we have gained his confidence, we should have no trouble at the completion of the work.

CURING THE DENTURES

The dentures are cured in injector flasks or spring clamps, but not in flask presses. They are cured for nine hours (overnight) in water at 165° F., then bench-cooled for an hour before cooling in water for at least fifteen minutes. If we do not have time for the overnight cure, we cure the dentures at 165° F. for one and one-half hours, and then boil them for thirty minutes. They are then bench-cooled for one hour and cooled in tap water for fifteen minutes.

Regardless of the curing technique or the material used, it is an advantage to allow the case to set after it has been pressed for at least an hour, before the curing process is started. It gives the plastic a chance to harden, time for the monomer to be absorbed by the polymer, and it seems to make porosity less likely to develop.

SPOT GRINDING

When the dentures are removed from the flasks after curing, they are not immediately removed from the casts. The casts with the dentures still on them are reattached to the other half of the split casts on the articulator (Fig. 22), and fastened in place, either mechanically or with plaster. Then, the points of interference in centric position are located with carbon paper, and are corrected with stones. Selective spot grinding is done in lateral and protrusive positions with small stones or diamonds. On the working side in lateral position, the lingual inclined plane of the buccal cusps of the upper and buccal inclined plane of lingual cusps of the lower are ground. That is, grinding is done on the buccal of the upper and lingual of the lower, "BU-LL". On the balancing side, either the lingual cusps of the upper, or the buccal cusps of the lower are ground. The bite is checked in protrusive to see that the incisors and molars contact at the same time. In centric, the upper and lower anterior teeth should not contact. Most cases are open ½ to 1 mm. on the incisal pin after curing and remounting. The occlusion is corrected until the incisal pin of the articulator is touching in centric position, and the case runs freely into all positions with no cuspal interference.

MILLING

The milling of the case is just a final refinement of contacting surfaces of the teeth. Abrasive paste is put on their occlusal surfaces. If the articulator has a milling device, it is put in motion, and the incisal pin is moved from side to side, and forward and backward. The amount of milling and spot grinding that is done on the articulator depends on the type of articulator that is used, and on the accuracy of the maxillomandibular relations that have been taken. If the records have been complete, and a fully adaptable instrument has been carefully adjusted, then the refinements of the articulation of the teeth may be completed on the instrument, and, when placed in the mouth, the results will be the same in the

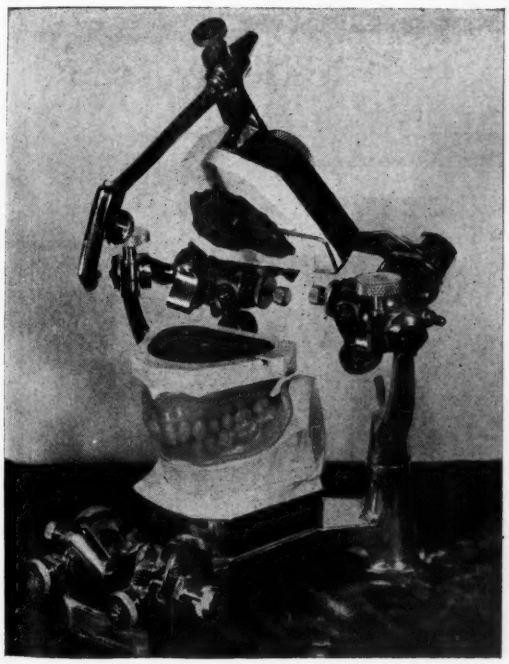

Fig. 22.—Remounting of cases after curing in order to correct any cuspal interference by selective spot-grinding and milling.

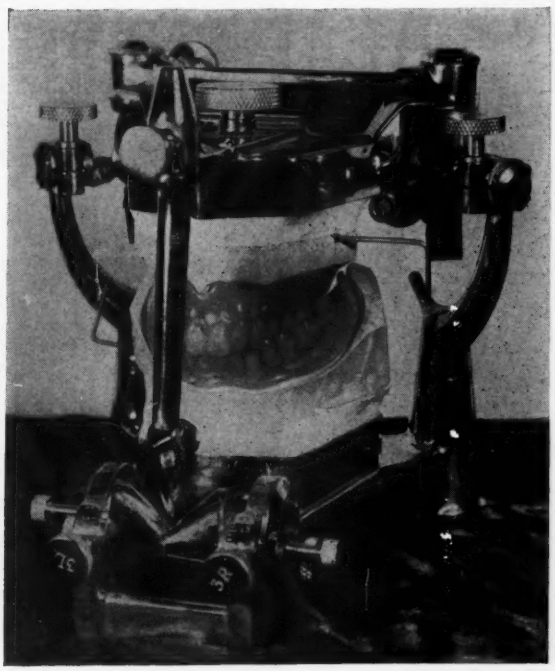

Fig. 23.—The completed case on the precision coordinator which was designed by the author.

mouth as on the articulator. If a nonadjustable articulator is used, no adjusting of the occlusion should be done except in centric position, as this is the only record which has been taken, and everything else is arbitrary. However, all teeth should be touching equally in centric position. It is better to do the corrections for lateral and protrusive in the mouth, when a nonadjustable instrument is used. If you are using a semi-adjustable instrument, one which has condylar path adjustments, the case can be balanced in protrusive and centric positions, and a certain amount done in lateral, since the condylar paths of the instrument do approximately follow the patient's condylar paths. A case that has been spot-ground

and milled on this type of instrument will require much less adjustment at the mouth than one which has been made on an arbitary nonadjustable instrument. If you have used a fully adjustable instrument, and have taken accurate centric, protrusive, and right and left lateral check bites, and have set the Gothic arch controls of the instrument as well as the condylar guidances, the case can be spot-ground and milled completely on the instrument, and when it is placed in the

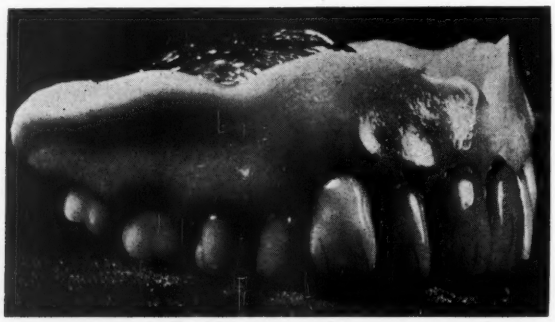

Fig. 24.—Lateral view of gold upper denture.

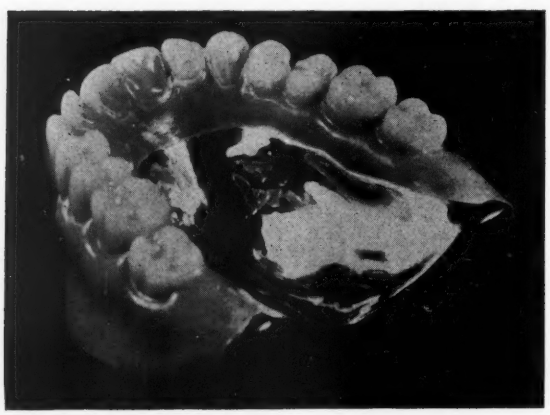

Fig. 25.—Complete upper denture with gold palate.

mouth, the patient will find no cuspal interference. In using the first two classes of articulators, the final adjustment of the teeth should always be done in the mouth, but this does not mean that a good end result cannot be obtained. It does mean, however, that all this work that could be done in the laboratory on the instrument must be done in the mouth. I cannot see how anyone who builds many dentures could say that an articulator is not valuable in the construction of dentures, and the more complete the articulator the more valuable its use. Selective spot grinding should be correctly done with the incisal pin in place.

Then, when using the coordinator (Fig. 23), set the grinder at 20. Apply milling paste and a little water to the occlusal surfaces of the teeth, and mill through all ranges of movement.

The milling merely smooths the contacting surfaces, and enables the teeth to glide smoothly through all positions without interference. This eliminates the soreness which is due to torque. The ground surfaces of the teeth are first polished with fine sandpaper discs, followed by pumice, and then porcelain polish on a hard felt wheel. Before polishing the teeth, the occlusal surfaces should be recarved with knife-edge diamond stones, or knife-edge Carborundum stones running in oil or water. Artificial teeth, when finished, should have sharp cutting edges, and not flat surfaces which can only mash food. If a patient cannot cut meat with a dull knife, how can he hope to chew it with flat smooth teeth? Far too little attention has been given to sharp teeth, and their relation to chewing efficiency. Artificial dentures, at best, are poor chewing substitutes for natural teeth. Anything we can do to increase their efficiency is important. The amount of pressure which can be comfortably exerted on dentures is only from 15 to 30 pounds, while patients can exert anywhere from 100 to 300 pounds pressure on natural teeth. For this reason, artificial teeth should be much sharper than natural teeth, in order to give the patient a reasonable amount of chewing ability. Flat contacting surfaces will not do this.

SEVENTH APPOINTMENT

Delivery of the Finished Dentures

The dentures are delivered and instructions given to the patient (Fig. 24). The patient will not experience any serious difficulties if he will refrain from heavy chewing during the first week, and there will be very little adjusting to do if these instructions are followed. An appointment should be made for the next day, and the mouth checked for any pressure spots. We use the material (Indicator Gel), which we used for our final impressions, to locate pressure spots, should there be any. It is well to give our patients a definite appointment each day or every other day following the insertion of the dentures in order to check the mouth, and to get the patients' reaction to the new dentures. Any misunderstanding which may be developing in their minds can be corrected then. Until they have gone through the adjustment period, our responsibility is not over. We should not release our patients until their mouths are perfectly comfortable, and they are happy with the results. Prosthetics is not easy, but it is, to me, the most interesting part of dentistry, and if it is well managed, can be the most remunerative (Fig. 25).

In conclusion, I would like to state that the results of a precision technique will be "Dentures That Fit and Function." Happy, satisfied patients refer more denture patients.

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THE USE OF THE PALATAL INDEX IN FULL DENTURE PROSTHESIS

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TOOTH position is the most important factor governing esthetics of a denture. Why not place the denture teeth in exactly the same relationship to lips and cheeks as existed in the favorable immediate dentures, and as existed in the favorable natural dentition?

The reproduction of tooth arrangement and arch form of a favorable natural dentition in dentures subsequent to immediate dentures is not simple. Such reproduction is less difficult, however, if a palatal index is used in combination with an exact locator. The palate is the most stable part of the denture-bearing area. The ridges extending from the lingual angle to the mucobuccal fold always change in size and shape, but the median-line area of the hard palate does not change appreciably. Therefore, the stability of that portion of the hard palate may be utilized in the reproduction of a favorable arch form, in the arrangement of teeth in immediate dentures, and in the proper positioning of teeth in all dentures subsequent to favorable immediate dentures.

DeVan[1] stated that the relative importance of details governing appearance are as follows: (1) position of the teeth, (2) form and size, (3) brightness and color, (4) shape, (5) tilt or inclination.

Jankelson[2] has shown that the tongue plays an important part in every masticatory cycle, not only in moving the food from one side to the other, but also in governing the act of swallowing. The movies shown by Jankelson made it readily apparent that when the tongue comes forward to expel excess air from the oral cavity, prior to the act of swallowing, the position of the anterior teeth would play an important part in assuring proper closure of the lips.

Wright[3] has shown that the most movable part of the tongue is the anterior third. Any crowding of the tongue in the region from the lower right bicuspid to the lower left bicuspid will hamper proper coordinated tongue movement and thus cause speech difficulties.

Thus, it is evident that a method for obtaining the proper position of teeth in the denture base is imperative for the elimination of speech difficulties, for the creation of esthetic dentures, and for minimizing tongue difficulties within the denture base area.

The most simple way to assure ourselves of proper positioning of the teeth within a denture base is by the use of a matrix former that fits an articulator and that produces an occlusal matrix of uniform size and lateral indices of the

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teeth, plus an imprint of the stable palatal portion with a definite means for orientation. The equipment used is an improved matrix former (see Figs. 1 and 2) which has a tapered plug (*E*) as an orientation for the palatal imprint.

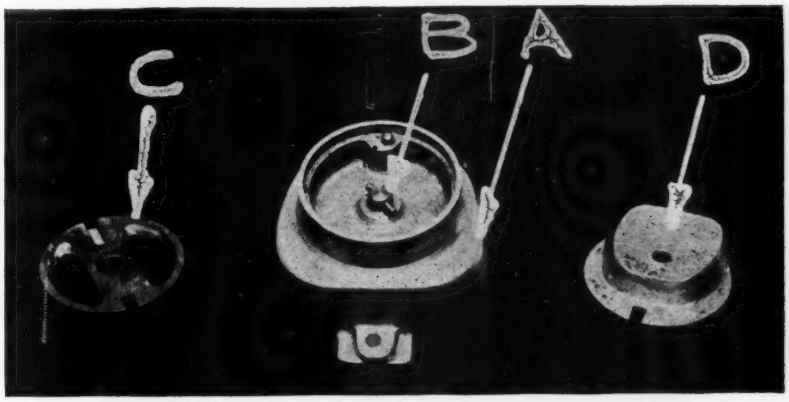

Fig. 1.—Bottom view of matrix housing (*A*) to show cast ejection screw (*B*), standard Hanau mounting ring with an additional locating slot (*C*), and an adapter for a Gysi Articulator (*D*).

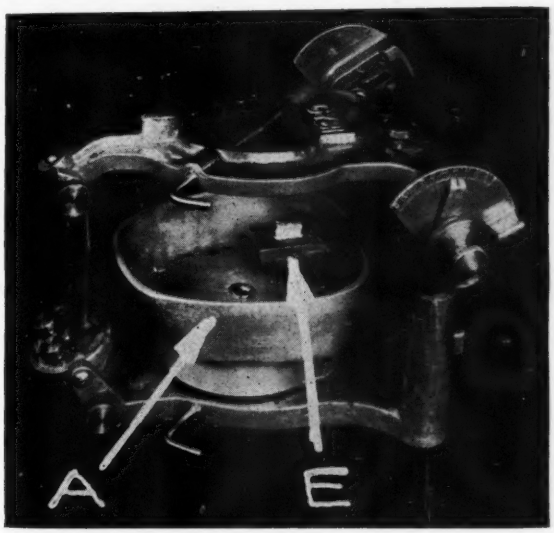

Fig. 2.—Matrix former housing (*A*) placed on a Gysi Adapter, and the orienting imprint former for palatal index (*E*).

PROCEDURE

1. The immediate denture to be reproduced is first corrected for vertical dimension by placing three stops of Kerr's green compound on the tissue side of the denture as follows: one in the incisal region, and one on each side in the second molar region.

2. The denture is thoroughly dried, and the inner palatal portion is painted with melted Kerr's Impression Wax, or Korecto Impression Wax. The wax-covered immediate denture is reinserted in the mouth, with instructions to cause the patient to close into centric position. The three areas of compound act as stops.

3. The denture is removed after allowing about five minutes for the wax to flow and is carefully examined to be sure that the entire palatal surface is registered, and that there is a glistening sheen on the wax. If a dull surface remains, more wax is added to the dull areas, and the case is reinserted for further correction. No effort is made to register the ridges in the wax at this time if an entirely new impression is anticipated.

Fig. 3.—Baseplate wax (*F*) adapted around the celluloid pieces (*G*) to box in the area desired for producing lateral indices of the teeth.

4. The ridge portion of the immediate denture is filled with wet, soft tissue paper. The denture, with the palatal portion corrected with wax, and the ridge area filled with paper, is boxed and poured in stone.

5. The denture with the cast is mounted to the upper member of the articulator with a face-bow transfer.

6. The upper denture is closed into the matrix former for the determination of the matrix plaster height desired, so that the plaster will register only the occlusal portion of the teeth.

7. The matrix former is filled with soft plaster of Paris, and the tapered plug for producing an orienting imprint is immediately inserted. The upper denture is closed into the soft plaster for production of the occlusal index. While the plaster is soft, five pieces of celluloid, one inch high and three-fourths inch wide, are inserted into the soft plaster one-half inch deep in the following manner: one piece is placed against the labial surface of the right cuspid, one against the labial

surface of the left cuspid, one against the labial surface of a central incisor, one against the buccal surface of the right second molar, and the fifth piece against the buccal surface of the left second molar. (See Fig. 3 [*G*].)

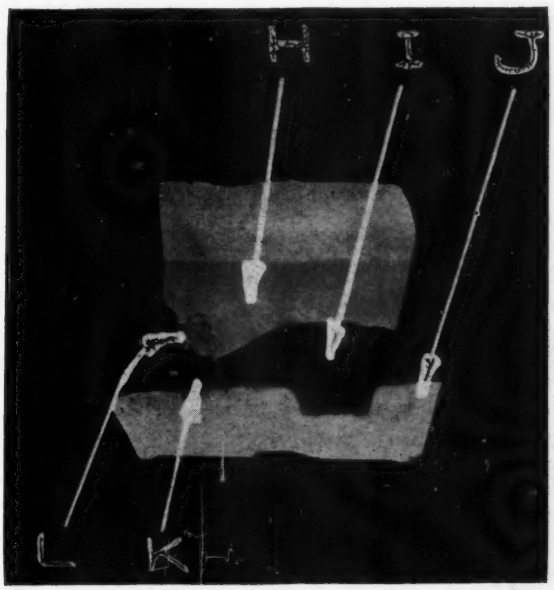

Fig. 4.—Section through the center of an occlusal matrix (*J*), through the center of the baseplate wax boxing (*K*), through center of the paper-filled ridge area (*L*), through center of cast obtained from immediate denture (*H*), and through center of palatal index (*I*).

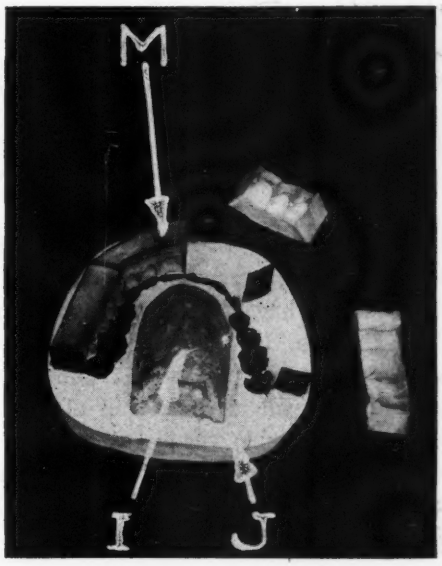

Fig. 5.—Partially assembled indices. Occlusal index (*J*) with the palatal index (*I*) in the orienting imprint, and with two lateral indices sections (*M*) in place and with two non-assembled lateral indices.

8. The exposed matrix surface, buccal and labial to the teeth, is then painted with a separating fluid, and the five celluloid pieces, which extend approximately three-fourths inch from the surface of the teeth, and about one-half inch above the occlusal matrix, are boxed in with baseplate wax. (See Fig. 3 [*F*].) This boxed area is filled with soft plaster to produce a labiobuccal matrix of the teeth.

9. The labiobuccal matrix is removed in four segments after the plaster is set.

10. The upper denture is carefully removed from the plaster matrix after first loosening the upper cast mounting device (screw on the Hanau Articulator, or a pin on the Gysi Adjustable Articulator), so that the upper articulator arm can be opened; and then the cast is raised carefully, with motion along the long axis of the anterior teeth, to prevent breakage of denture teeth.

11. The denture is thoroughly cleaned and polished and is returned to the patient. The time consumed to this point is about one hour.

12. Only the accurate palatal portions of the cast are boxed in, using baseplate wax of sufficient height to satisfy the vertical height determined by the articulator guide pin.

13. The entire occlusal matrix and palatal cast is painted with separating fluid, and the articulator is closed, carrying with its upper member the palatal cast of the immediate denture and its wax boxing, into the proper relationship with the matrix.

14. Stone is poured into the boxed palatal cavity to produce a palatal index. (See Fig. 4 [*I*].)

15. The upper palatal cast, made with the aid of the immediate denture, is discarded after the palatal index is made.

16. A totally new impression is made of the upper edentulous arch, and a cast is produced in dental stone.

17. The cast is placed in its exact position on the palatal index, is waxed to place, and is mounted to the upper member of the articulator.

18. The matrix is completely reassembled with the four labiobuccal surface matrices (see Fig. 5 [*M*]), the palatal index (*I*), and the basic occlusal index (*J*).

19. Teeth of the same mold as those used in the original immediate denture are selected and ground to fit the occlusal and the labiobuccal matrices as nearly as possible.

20. The teeth are placed in the matrices and waxed to an upper baseplate on the stone cast which was made from the new impression.

21. The second denture will have the same arch form, the proper vertical height, the same tooth inclination, the same tooth mold, and the same tooth irregularity of the original immediate denture at the try-in.

The matrix former with the palatal index can also be used for duplication of dentures, for transferring a favorable vertical dimension existing in a natural dentition from pre-extraction records taken years before a denture was necessary into denture construction, for remounting denture cases on the articulator without the necessity of a new face-bow transfer, and for reproducing the favorable position of natural teeth in denture construction.

Since the palate is the least changeable part of the denture area, why not use it to our advantage?

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CENTRIC POSITION

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AMONG the many concepts in denture construction which have been accepted by the profession, the concept of the centric position stands out as the vaguest and most ambiguous, although certainly one of the most important. Most definitions are based on clinical observations with consequent interpretations of the actual situations. If one is to define centric relation, it must be done anatomically since it is basically an anatomic study. A definition of this relation which embodies the anatomy of the area was suggested by Thompson,[1] who discussed the three mandibular positions, viz., the rest position, the occlusal position, and the centric position. He is of the opinion that the centric position cannot be described in a few words, but that it is a concept that must be understood in order to be applied clinically. He says:

"The centric position cannot be formulated in a definition with a few words, but rather it is a concept that must be understood. Centric position is not only the mandibulo-maxillary relation where the teeth should occlude in the normal or good functioning situation, but also where the condyle of the mandible is in a balanced and unstrained position in the mandibular fossa. This position exists when the antero-superior surface of the condyle is in close approximation with the postero-inferior surface of the articular eminence. This relationship does not vary much in individuals under normal circumstances, but the space posterior and superior to the condyle does vary in size. If the path of closure from rest to the occlusal position is normal through an acceptable interocclusal clearance, the occlusal position will be identical with the centric position. If the path is abnormal because of tooth interference, or if the interocclusal clearance (free-way space) is too small or absent or, on the other hand, too large, the occlusal position will not be identical to the centric position, and an abnormal functional situation will exist."

This definition differs from the usual type of definition of this relationship in that it does not show how to establish a centric position, except that it can be more likely established if it is understood on an anatomical rather than an empirical basis. It also does not insist, as so many of the definitions do, upon *retrusion.*

I would like here to emphasize the fact that a mandible—anatomically speaking—can be retruded beyond what we should consider centric into a strained retruded position. This has always been generally accepted. There is a space distal to the condyle which contains soft tissue and the nutrient supply to the temporomandibular joint, when the mandible is in its normal rest position and occlusal position. This area can be encroached upon by a forced retrusion. We have here introduced another important factor which is physiology. Since the mandible can be retruded anatomically by conscious effort, or if it has been occluding in a position

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of posterior mandibular displacement because of occlusal interference, what happens when a denture is constructed to these posterior positions? If patients are observed with this possibility in mind, the practitioner will find the existence of abnormal functional situations similar to the following.

In the first type, the patient had been wearing a partial lower denture which occluded with natural upper teeth. The denture had been constructed to the popular concept of the centric relation which emphasized retrusion and forced, therefore, a retruded relation whenever the teeth were brought into occlusion. The patient presented with symptoms of clicking in the joint, tiredness around the jaws and face, and inability to use the appliance.

Cephalometric radiographic examination showed no obvious deformation of the condyles, and made certain that the occlusal vertical dimension was adequate but not excessive. It did reveal an abnormal posterior-superior path of closure from rest to the occlusal position.

Believing that a retruded relation existed, the patient was asked to move the mandible slightly forward from this position so that the occlusal position was identical with the centric position, and after covering the occlusal surfaces of the partial denture with a self-curing acrylic the patient held this new relation until it was registered permanently on the appliance (three minutes).

By studying the patient over a period of weeks, and by judicious spot grinding, the acquired improper closing pattern which caused a retrusion of the mandible, and an encroachment upon the soft tissue was broken, and the symptomology began to disappear.

A new partial lower denture was constructed. The upper cast was mounted by a face-bow on a Hanau articulator, and the lower cast was mounted to the relation established in the old appliance. Teeth were set to this position, and ground in to eliminate gross interference. At the try-in of the metal framework with the teeth set in wax, adjustments were made to provide for comfort and balance. The denture was subsequently completed. The patient, after a few adjustments to relieve points of interference, was asymptomatic and able to use the appliance. It is interesting to note that three months later it was still possible for the patient to close into the retruded position, but at this time it felt uncomfortable and abnormal, and a normal anterior-superior path of closure from rest to occlusal position had been restored.

The second type of abnormal functional situation concerned a complete upper and lower denture. The patient had been edentulous for twelve years, and had been wearing dentures throughout that period. The dentures with which she presented were constructed three years previously, but could not be used efficiently. Here, again, the patient presented with a clicking in the temporomandibular joint, pain, and an inability to wear or use the lower denture. Cephalometric radiographic examinations were made to determine the adequacy of the occlusal vertical dimension and lack of condylar deformation, and an abnormal posterior-superior path of closure from rest to the occlusal position was noted. An autopolymer was placed over the lower teeth, and the jaw was manipulated forward, with the help of the patient, into what was believed to be the correct occlusal relation. In this case the

symptoms were slightly lessened. It was decided to construct a denture to this occlusal position with the thought that it would be identical to the centric position.

The dentures were constructed in the usual way. The relation of the mandible to the maxilla that was obtained approximated the relation which was built into the old dentures by the addition of the autopolymer. Teeth were set up to this relation and, because of the fact that the patient appeared to have been in a retruded position, deep cusp teeth were used to help guide the mandible into its proper relation. The cephalometer was used to check each step along the way, and the upper denture was processed. The final centric relation was determined at this point. The occlusion on the lower denture was modified to accept this relation, and the lower denture was processed.

Occlusal adjustment of the completed dentures was done in the usual manner, and the dentures were inserted.

The tiredness, clicking, and inability to use the dentures disappeared almost immediately. Four months later, the patient could be forced into a retruded relation, but it was becoming more strained and uncomfortable in this position. A normal anterior-superior path of closure from rest to occlusal position had been restored. This was a change from the abnormal posterior-superior path of closure that existed when the occlusal position of the jaw was posterior to the centric position.

CONCLUSION

Anatomically, it is possible for the mandible to be in a strained retruded position, and in a position of posterior displacement when the teeth are occluded.

Physiologically and functionally this position leads to a classic symptomology, namely: crepitus, pain, and tiredness of the jaws. By careful manipulation of the mandible, a new centric position which is closer to the normal physiologic relationship can be established. By watching and adjusting this position, an acceptable centric relation can be established.

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CONDYLAR PATH BY ROENTGENOGRAPH

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THE technique to be described in this article is the beginning of a study of a method to record the condylar path by roentgenograph. X-ray films have been used to provide a more visible approach to the biology of the temporomandibular joint.

For some time the condylar path has been used as a guide for adjustable articulator techniques to aid in the arrangement of teeth in occlusion. Generally, the condylar path has been determined by the functional movement of the mandible. Registrations have been made of various positions of the mandible, and these registrations transferred to an articulator by adjusting the simulated condylar paths.

In most techniques, guides such as the central-bearing, occlusal guides, or tooth surfaces may affect the registration records within the functional range. The registration of the condylar paths recorded from the oral cavity is a composite result of the paths of both condyles. Because these techniques are used in the same area in which the tooth occlusion is to be placed, a functional occlusion may be provided. However, there are variables which could affect the condylar path recordings. If the patient moves the jaw laterally in protrusive movement, the registration of the condyle path is changed. If the central bearing is not located at the central point, registration of the condylar path could be affected.

The anatomy of the temporomandibular joint provides, in the normal case, quite a range of functional tolerance. There is a meniscus or interarticular disc anterior to, and partly superior to the condylar head, and connective tissue distal to and partly superior to the condylar head. The entire joint is encapsulated by tendonous connective tissue. These tissues vary in thickness and permit a variance of movement in the joint, depending upon thickness and upon the amount of displacement during movement.

The meniscus is avascular, pressure-bearing tissue. The connective tissue distal to and superior to the condylar head contains blood vessels and nerves and is non-pressure-bearing. Abnormal pressures on the distal part of the fossa may result in pain. As the condylar head functions in a glide, the bearing is transmitted through the meniscus to the anterior section of the articular fossa. The anterior section of the articular fossa is the articular tubercle which is osseous structure, and may be considered the basic guide for the condylar path.

The glide of the condylar head may be compared to a vehicle moving over a road. The road bed may be the basic factor of its movements, but movement of the body of the vehicle is modified by springs and tires. The anterior section of

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the articular fossa is the basic guide of the condylar movement, but the movement is modified by the soft tissue parts of the joint.

The temporomandibular x-ray film discloses the temporomandibular joint and indicates the angle of the anterior section of the articular fossa, as well as the position of the condylar head. It also indicates the amount of space between the condylar head and the articular tubercle which would approximate the functional tolerance within the joint.

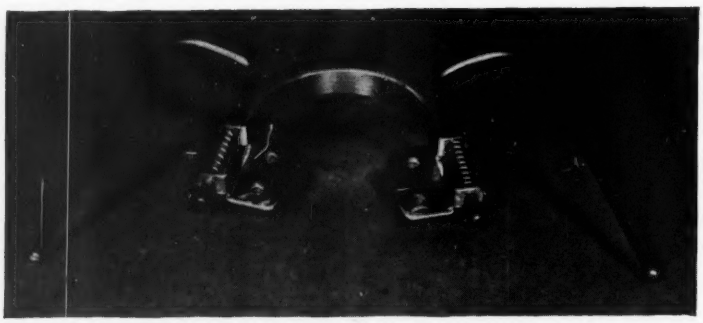

Fig. 1.—Metal form to fit occlusion rims, with the lateral steel index rods. Use modeling compound for seating in dentulous cases.

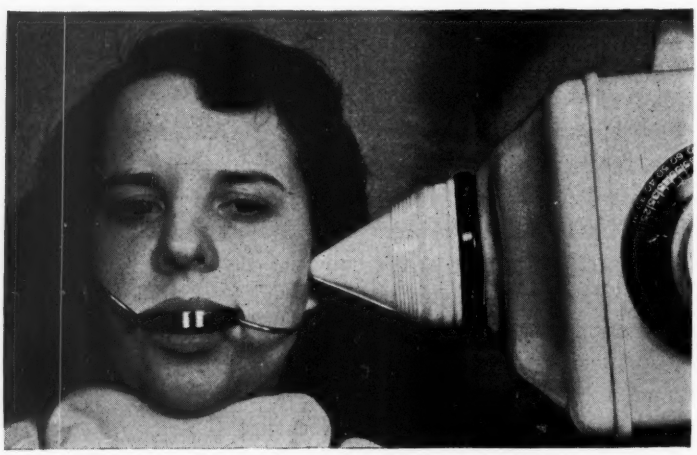

Fig. 2.—Rods in place and the x-ray cone at the sigmoid notch.

The temporomandibular x-ray film indicates the actual form and angles of the osseous structure of the joint. Functional registrations indicate the condylar path angles as they might be because of the resultant jaw relations. By examining the angle of the osseous structure of the joint directly on the film, and making a transfer from the film to the instrument, a more specific condylar path angle can be determined.

There are many excellent x-ray techniques of temporomandibular joints which have been suggested for this technique. At this time, a technique has been selected which permits the central x-ray to be as close to a horzonital plane as

possible, and provides a picture of the angle of the joint without interference.* The technique was selected because it requires the least involved equipment, and can be used in the average dental office.

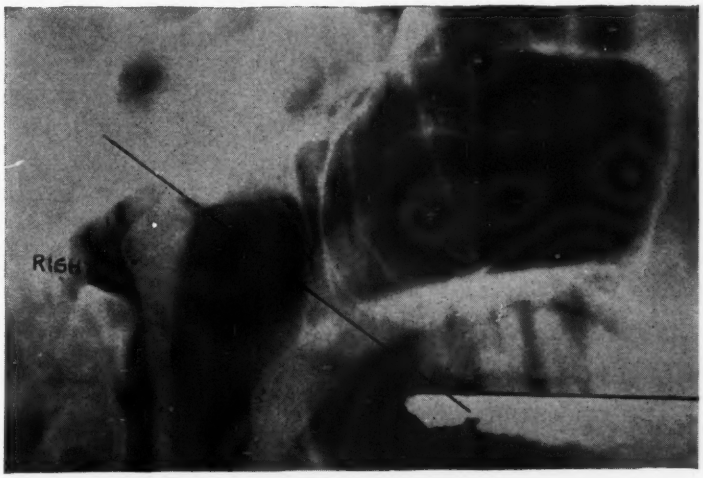

Fig. 3.—X-ray film with lines extended on the rod area and along the angle of the condylar path.

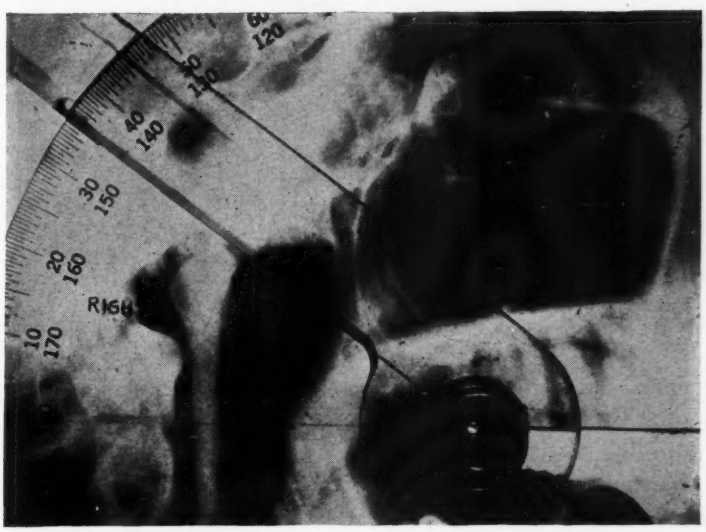

Fig. 4.—Protractor in position for reading the angle of the condylar path.

In order to have the x-ray film of the temporomandibular joint be of practical value, a technique was devised to transfer the measurement of the angle of the osseous structure of the joint to an articulator. A metal form was devised which would fit onto an occlusion rim or onto natural teeth which may be present. (See Fig. 1.) Two steel rods, 1/16 inch in diameter, are attached on either side

*McQueen, W. W.: 1938 Yearbook of Radiology, Chicago, 1938, the Yearbook, Inc., p. 86.

of the metal form. The rods are arranged so that they may be placed at the side of the face below the temporomandibular joint. They are U-shaped with straight end segments. They are attached to the metal form so that they may be set at the Fox plane. The Fox plane extends from the tragus of the ear to the ala of the nose and provides an anatomic landmark on the face. The rod on the side of the head which is being x-rayed is placed in position on the Fox plane, and the opposite side is dropped down. The patient's head is supported in a normal, upright position as used in a routine upper dental x-ray technique. (See Fig. 2.)

An examination of the head is made by palpation to locate the sigmoid notch which is below the zygomatic arch and about twenty millimeters forward of the auditory meatus. When the mandible is opened or closed, the position of the sigmoid notch changes which should be considered for the location of the x-ray

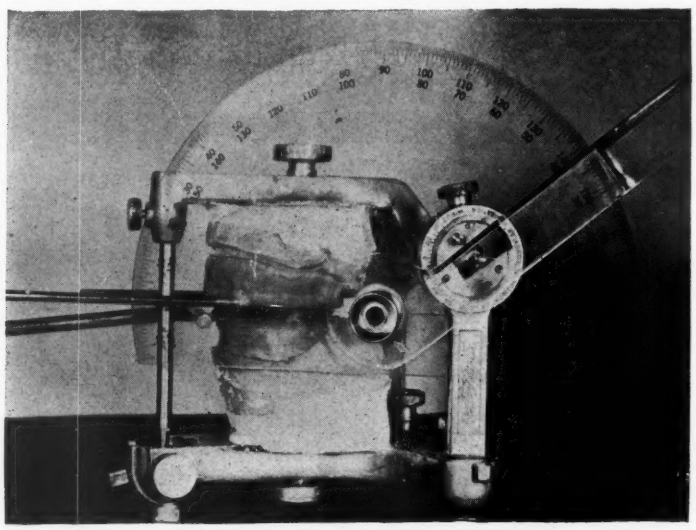

Fig. 5.—Protractor in position for checking the condylar path on the articulator mounting.

cone and the direction of the ray. The cone of the x-ray is placed at the sigmoid notch area and is directed at the opposite temporomandibular joint. A mark placed on the face at the location of the sigmoid notch, and one placed on the opposite side of the face at the location of the temporomandibular joint aids in lining up the central ray.

The x-ray cone end is placed at the mark over the sigmoid notch, and the central ray is directed at the temporomandibular joint on the opposite side of the head. This results in an angle of approximately eight to twelve degrees from horizontal.

A 5 by 7 inch x-ray film in a film holder without intensifying screens is held at the side of the head opposite the cone at right angles to the x-ray tube. For the average person, the suggested exposure is 8 seconds, 110 milliamperes, 110 volts, and 65 peak kilowatts. The time and exposure may be varied when cassettes with intensifying screens are used.

The developed film should show the steel rod as an opaque line, and the temporomandibular joint with the angle of the articular tubercle of the fossa. The measurement of the angle of the condylar path is made in degrees on the developed x-ray film. An ink line is drawn along the top of the shadow of the opaque rod which extends across the film. A second line is drawn along the

Fig. 6.—Skull with steel rod indicating the clear area path for x-ray.

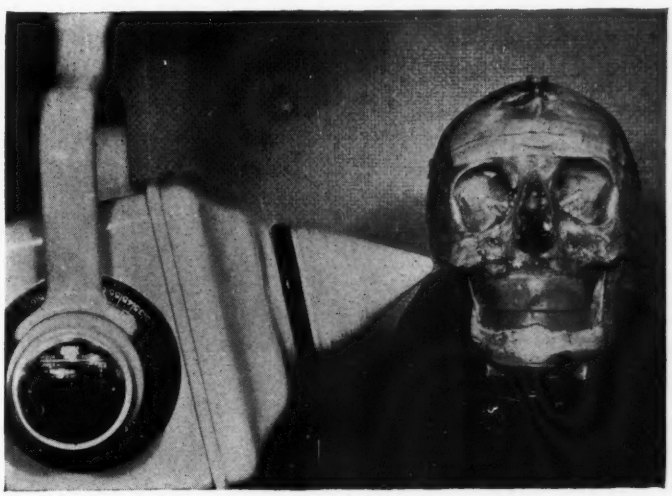

Fig. 7.—Cone of x-ray in proper position at sigmoid notch and directed to opposite temporomandibular joint.

lower border of the articular tubercle, and is extended to cross the line drawn along the shadow of the steel rod. This creates the angle of the condylar path to be used for articulator adjustment. (See Fig. 3.) Sometimes the angle of the bone indicates curves, and it is necessary to use the mean of the indicated angles as is done on many articulators which are available. It may be that a technique could be worked out to follow the variations in the fossa.

A protractor is used to read the angle between the two lines on the film, by placing the 0 degree to 180 degree line along the line of the steel rod, which is on the Fox plane. The center radius of the protractor is placed at the point of the angle created by the two lines on the film. The angle of the condylar path is then registered in degrees on the protractor. Example: +35 degrees left, +39 degrees right. (See Fig. 4.)

The transfer from the mouth to the articulator is made by a face-bow. The seating for the metal form which holds the rods is preserved when this form is removed and the face-bow placed in position. The face-bow then provides for the transfer to the articulator in the proper relation to the hinge axis of the instrument. After the casts are mounted, the metal form is placed back in position on the occlusion rims with the steel rods in the same relative positions as they were on the head. The protractor is used again by placing the 0 degree to 180 degree line along the top of the steel rod, and bringing it back to the condylar path adjustment mechanism. The condylar path angle is established by adjusting the horizontal condylar path mechanism of the articulator to coincide with the angle recorded on the x-ray film. (See Fig. 5.) The angle thus established is checked by registrations from the mouth after mounting the casts.

To determine whether there may be distortion in the film registration because of the angles of the central ray, x-ray films were taken of a skull following the same procedure as used on the patient. The film was developed and the angle of the condylar path was determined. (See Fig. 6.) Then a steel rod was mounted into the articular fossa and placed against the anterior slope of the articular tubercle. This provided a steel rod mounted on the maxilla by the base plate and a steel rod mounted at the angle of the articular tubercle. The angle between the steel rods was measured, and found to be approximately the same as that determined by the x-ray. (See Fig. 7.)

CONCLUSION

The procedure is a means for providing a registration of the condylar path on the articulator. It is a method which permits the use of the present adjustable articulators, without an apparent need for a new design of articulator, unless we wish to use the curves of the condylar path.

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THE MEASURED VERTICAL DIMENSION AND DENTURE ADHESIVE POWDERS*

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THE superlative for logical dental reasoning during the first half of the present century might be awarded to Dr. John Hunter for his views on the theory of dental foci of infections, and to Dr. Gysi a close second for his studies of the geometric movements of the mandible. However, it is not the intention of this paper to dwell on the work of either of these men, but to discuss in part a practical sequence of their combined achievements.

At the turn of the century the profession of dentistry was confronted with the problem of keeping dentures stable on their ridges. Springs, gum tragacanth, vacuum chambers, and Eureka suction cups were employed to supplement work done at the chair.

Hunter's statement obviously added to the number of these devices, but more particularly to the output of denture adhesive powders which were to become so universally employed. As a corollary, the relatively high cusps of Gysi's new and geometrically carved bicuspids and molars contributed indirectly to the denture adhesive powder output because of the inability of dentists to properly articulate them. The use of high cusps should not be construed as the sole cause of the use of adhesives, but as one of many diverse contributing factors. In all probability the profession during the first half of the century gave no thought to the role denture adhesive powders play in prosthodontia or to what their growing use implied. Nor does it today. This cannot be said of the manufacturers of this product. To the producers it has become the big legitimate business it now is.

How the full impact of Hunter's edict affected the trend of dental thought of that day was reflected in the program of the newly organized National Society of Denture Prosthetists which met in Boston for the purpose of discussing "Geometry in Articulators;" "Esthetics and Art;" "Mouth Examination and Impression Making;" "Classification of Mouth Tissue Conditions and the Treatment Indicated;" "Technic;" and finally, "Business Methods and Education of Patients in Wearing Artificial Dentures." At the meeting Dr. Gysi was the rotation center around which the articulator discussion revolved; a revolution which has not as yet lost its momentum. From then on until today articulators seem to have absorbed the attention of prosthetists to the point of being made a major prosthetic issue to the exclusion of more important phases of the work. Actually the role of the articulator

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in the prosthetic scheme is a minor one. A simplex articulator should suffice for all but a small number of cases. Human errors in diagnosis and inaccuracies in technique at the chair are more conducive to denture failures and to the use of adhesives than any mechanical malfunction of articulators.

That midcentury prosthetic reasoning comparable with that of the earlier temperamental theory of tooth selection still prevails in the prosthodontic mind is manifest in present-day literature.

As with practically all technical achievements whose development has been spurred by actual necessity, prosthodontia is coming up the hard way and is still muddling through trial and error. It limps along from day to day, its shortcomings rather obvious to the patient, though perhaps not so obvious to the dentist.

Today the question arises: has prosthodontia consolidated the gains of Hunter, Gysi, and Leon Williams? The answer is an emphatic *no*. Evidence of this lack of uniform success can be found in daily journals and current magazines which advertise adhesive powders for the purpose of keeping full artificial dentures in position during speech and mastication. Answers to letters of inquiry addressed to adhesive powder manufacturers regarding the number of such plants in America and their approximate annual output were frank, revealing and interesting.

The replies submitted by the various manufacturers are duly acknowledged here and are in part as follows:[1]

Years ago the common gums used in denture powders were tragacanth, arabic, and acacia. They were used singly and in combination.

The powders had several drawbacks—they were too mucilaginous and too soluble in contact with saliva; they seeped out, were ill-tasting, and were swallowed.

Gum karaya with small additions of acacia and arabic to prevent seepage is now the powder of choice.

Karaya is not water soluble and lasts longer. Denture powders have been described as adhesives which they are not in the mucilaginous sense. Their function is to establish a temporary peripheral seal for denture retention.

In 1939 thirty manufacturers were producing more than $2,500,000 worth of adhesives annually. From the same source we also learn there were 15,000,000 denture wearers in the United States. The powder users are grouped as follows:

1. Those who because of the peculiar shape of their mouths are unable to obtain dentures which afford much suction.
2. Nervous patients requiring additional assurance of complete comfort.
3. Those who cannot afford an accidental slip of their dentures, such as attorneys, actors, public speakers, etc.

The foregoing statement in a sense constitutes an indictment of the dental profession. The inescapable inference is that uniform success with a large number of dental restorations has not been achieved by the profession as a whole.

What is needed is a new concept of responsibility in a matter essential to the public welfare and a recognition that such conditions are intolerable when the problem is thrown into the laps of the powder manufacturers for solution.

In support of this statement we have seen new commercial enterprises develop and thrive for the purpose of supplementing our professional shortcomings.

We also have evidence of new improvements in types of denture adhesives by more recent entrants into this field, such as amazing new creams that lessen the constant fear of dropping, rocking, and chafing plates.

Add to the foregoing a questionnaire submitted by Dental Survey Publications[2] asking what brand of denture adhesive do you recommend? No doubt the honest assumption of the publisher is that denture adhesives are here to stay; coming from the well-considered perspective of a businessman, he is probably correct in that assumption.

It is equally true that well constructed dentures do not require adhesives or any extraneous suction devices.

The foregoing are facts that imply failure and the relegation of ourselves to a secondary role, which some day may become a cold hard reality; for recognition we may be required to pass a specialty board for Dental Prosthesis. They raise the question, can we avoid this blundering which must be recognized and understood? Our professional policy must be derived from our strategic situation. From this objective we must not be turned back either by the complexities of the task or by weakness in ourselves. To achieve this we must initiate radical and standardized changes in teaching and in technique—the one course to success is a logical analysis of the various steps in denture construction.

It is not the purpose of this paper to set up a formula or a simple method encompassing a complex technical problem, but to break the problem into units for further examination and better understanding.

Full denture cases that come within the range of the prosthodontist may be divided into three groups. The first is of patients who are to become edentulous and for whom the mouth must be prepared for the reception of dentures. Those in the second group may have either an edentulous maxilla or mandible. In the third group they are completely edentulous.

DIAGNOSIS

Before construction begins, each case within this category should be subjected to diagnostic acumen of a high order, i.e., from a roentgenologic, study-cast, and surgical viewpoint, before it reaches the impression stage in order to obviate possible flaws and inaccuracies that compel the use of powder in the finished case.

The initial unit for investigation should begin with roentgenographic interpretation using films for the entire mouth which may disclose evidence of osteomalacic diseases that influence rapid atrophic changes and denture instability, root tips, impactions, cysts, and other forms of gross pathology impedimental to successful prostheses.

The second unit to consider should be study casts — edentulous and dentulous. Edentulous casts require critical examination. To the discerning diagnostician they reveal many forms of atrophy and hypertrophy of bone and soft tissue such as senile bone atrophy, sharp oblique ridges in the mandible, thin high and sharp

remnants of bone in both processes, soft tissue hypertrophies, tori, asymmetrical ridges, osteodystrophies, incompleted surgical ridge preparation, etc., any of which could undermine a finished denture and result in the use of adhesives. A cardinal prosthetic blunder is committed when pre-extraction casts are omitted of teeth about to be extracted. Detailed impressions of both jaws should be obtained. The brief time taken for this purpose will return important diagnostic and mechanical aids for the slight effort involved. The casts will disclose important aspects of the pre-existing order of the natural teeth and their anomalies if any be present. The size, shape, alignment, and arrangement of teeth are thus available for study away from the mouth. The most significant item they contain is a record of the vertical dimension, the technical use of which will be described in a succeeding step.

Surgery is the third preparatory step; it is pivotal and it is incumbent upon the surgeon to correctly interpret the x-ray films and the study casts. His objectives should be the removal of the teeth and pathologic tissue, and the adequate preparation of the ridges. He should have a due consideration of bone conservation and also for atrophic changes attending the loss of the teeth and alveolar process. Three millimeters of alveolar bone should be removed to allow for the thickness of the baseplate material, the pins, and ridgelaps of the artificial teeth. The maxillary papilla of the rugae should be conserved as a landmark or point of beginning from which the vertical is to be measured and recaptured.

At times, these factors are slighted and the preparation of the ridges is inadequate—routine x-ray rechecks and postextraction casts will disclose these inadequacies. Exodontia and prosthodontia are so entwined that any shortcomings of the former are more than likely to damage the plans of the latter.

IMPRESSIONS

Impression taking, usually regarded as the first step in denture construction, is actually its fourth. Opinion varies widely as to how impressions should be obtained. From standpoints of accuracy and economy of time prepared plaster is the ideal, as it does not overcompress the soft tissues. It should be noted here that a stiff plaster mix will overcompress the soft tissues.

Prepared plaster impression material, when set, is incapable of distortion. The maxillary impression when finished requires no further manipulation at the chair except relieving. As with any full impression technique, the mandible may at times require a snap impression and a cast over which to form a mandibular tray. With the use of plaster it often happens that simple methods succeed where complicated measures fail.

JAW RELATIONS

Recording centric relation is one of the most exacting tasks in denture construction. It is a step in which the most inaccuracies occur and contribute to denture failures. Its importance is not appreciated by dentists in general as it should be. Thousands of dentures are constructed annually that require adhesives

in which the vertical dimension was not properly secured. Establishing the vertical dimension is only one step in recording centric relation. It must be divided into its maxillary and mandibular components in order to establish the occlusal plane.

Failure to regard these vertical and horizontal lines as an integral entity will lead to clinical disaster. The length of the vertical cannot be varied more than one millimeter with impunity, nor can the division of the line by its occlusal plane, termed "Vertocclusion," be slighted. Its exact location must be predetermined. The correct establishment of the occlusal plane is of much greater significance than can be appreciated at a glance because it insures that the force exercised in mastication at each closure of the mandible and repeated many times daily will be distributed in a manner which will be the least destructive to the tissues that support the dentures. It acquires a double significance when one reflects that artificial teeth set to an accurately integrated occlusal plane will minimize spot grinding, obviate the use of check bites, extra-oral records of the downward inclination of the condyle paths, and the more recent attempts to register these inclinations roentgenographically. Significant movements of the mandible are made, not away from the maxilla, but toward it.

When the jaws are freed from the controlling action of the cusps of the teeth, the mandible makes a universal excursion and returns on varying rotation axes until the cusps of the teeth again come into contact; obviously, any check bite or roentgenographic record of the degree of inclination of the downward path of the condyle has no practical value; the path of the lateral movement alone has value in the articulation of artificial teeth.[3]

Any impediment can be attributed to faulty articulation, an overlengthened vertical dimension, and its concomitant unbalanced occlusal plane. Almost every phase of prosthodontia has been investigated (with the possible exception of the unmeasured vertical dimension) in ineffectual attempts to solve the prosthodontic riddle. Measuring the vertical dimension and recapturing it with millimeter accuracy may keep our prosthetic thinking straight.

The interalveolar crest line derives its name from Gysi. This entity is now described as the "vertical." The eruption of the mandibular and maxillary first molars determines the height of the vertical dimension and the location of the occlusal plane; the latter remains invariable throughout life. The length of the vertical, because of atrophic changes in both processes, varies in length from 10 to 28 millimeters. Regardless of alveolar bone atrophy when the teeth are present or following their loss, the original position of vertocclusion remains invariable.

The economic waste, loss of professional prestige, and a 20 percentage of denture "makeovers" must be given serious consideration, particularly when the vertical is so easily recorded and recaptured with millimeter accuracy.

In the edentulous state its point of beginning is the papilla of the maxillary rugae in the median line of the maxillae. It ends at a point on the mandibular ridge crest in the median line. It varies in length from 10 to 28 millimeters. According to Gysi, who stated at a time when the surgical preparation of the

ridges was not well understood as it is today, "It is rarely if ever practicable for prosthetists to make artificial dentures which restore the original height of the bite."[4] His method of measuring the vertical is not clear when he further stated, "In all cases the height of the bite was tested by the facial expression and the ability to pronounce clearly. For some patients the height of the bite could not exceed ten millimeters."[5] It is common practice today to do an alveolectomy to compensate for the thickness of the baseplates and ridge laps of the artificial teeth, in all cases where the vertical dimension is ten millimeters.

When the vertical dimension is to be restored following extractions of the teeth, one millimeter is the allowable variation from its original length. A practical method of recording and recapturing the vertical is by the use of pre-extraction casts. When these are omitted, its accurate recapture is, in most instances, irrevocably lost. It can be recovered from dentures about to be discarded, their long habitual use having fixed the dimension.

When these aids have been lost a hazardous attempt at its recapture can be made by placing a mark on the maxillary occlusion rim one millimeter above the rest line of the upper lip; a similar mark is made on the mandibular occlusion rim one millimeter below the rest line of the lower lip. These marks are used as points from which to establish an arbitrary interalveolar crest line or the vertical.

RECOVERING THE VERTICAL FROM PRE-EXTRACTION CASTS

The vertical dimension is recovered from the pre-extraction casts by placing one point of the compass on the ridge crest in the median line of the maxillary cast at the elevation of the papilla of the maxillary rugae, the other on the ridge crest of the mandibular cast in the median line for transfer to a millimeter gauge for recording.[6]

RECAPTURING THE VERTOCCLUSAL PLANE WITH THE OCCLUSAL RIMS

The vertical actually consists of two parts—a maxillary and mandibular component. They should be divided accurately.

The vertical length in millimeters of the maxillary occlusal rim can be taken from a maxillary central incisor on the cast, from the original extracted incisor, its artificial substitute or from a mark drawn on the occlusion rim in the median line one millimeter above the lip line in repose. One beak of the caliper is placed inside the occlusion rim at the location of the papilla of the maxillary rugae in the median line. The other beak is placed outside on the labial surface of the occlusion rim at a point in the median line corresponding to the length of the central incisor to be used. With this point as a target, the occlusion rim is heated and paralleled anteroposteriorly with a line previously drawn on the face from the lower border of the external auditory meatus of the ear to the ala of the nose and laterally with an imaginary line drawn through the pupils of the eyes.

The dimension of the mandibular component is obtained by heating its occlusion rim and closing it against the maxillary component to a predetermined

vertical dimension taken in millimeters from the casts, using the location of the maxillary papilla as a point of beginning and the median line of the mandibular ridge crest as its ending point. When the vertical dimension and the occlusal planes have been established with fidelity, artificial teeth set to these dimensions will have occlusal clearance which is automatically re-established.

Accuracy in establishing the occlusal plane is obviously important when artificial teeth are to be set to it. A vertical biting force directed against the oblique surfaces of the teeth set against an incorrect occlusal plane will result in a horizontal thrust that tends to dislodge the dentures, accelerate ridge resorption, and invite the use of adhesives. The vertical dimension may be lost by the omission of pre-extraction casts, by lengthening its dimension for cosmetic effect, by relining, rebasing, or being totally oblivious to its existence.

Involvements pertaining to relining immediate dentures are serious enough to warrant discussion under another heading. Suffice it to say relining or rebasing immediate dentures lengthens the vertical dimension and overcompresses the soft tissues and bony ridges of the supporting structures, as well as those comprising the temporomandibular articulation.

The added impact of intermittent pressures resulting from closing the mouth many times daily traumatizes these highly vascularized tissues and induces a pressure atrophy.

A comparison of the prosthetic occlusal plane with the curve of Spee will be revelatory. The function of the curve of Spee is to maintain the occlusal surfaces of the teeth at right angles to the line of closure of the mandible.

When natural teeth are in good positions and condition, there is a nice balance and adjustment of their occlusal surfaces in functional movements, so fine that the loss of a mandibular third molar may affect the articulation and traumatize the mandibular lateral incisor on the opposite side. A hard, high, unyielding gold inlay or a high amalgam filling will likewise controvert the function of the curve.

The cumulative effect of the staggered loss of teeth will result in a progressive articular inbalance which may require splints for correction in cases of acute temporomandibular arthrosis. In hypo-ostotic cases involving natural teeth because of a combined bone and soft tissue calcium deficiency, a resulting lowering of the vertical dimension will induce subjective symptoms of articular crepitus, discomfort and pain common to this arthritic syndrome.

Returning to the prosthetic occlusal plane to complete the comparison, it can be said that the external pterygoids are the principal muscles in opening movements of the jaw. The masseter muscles come into action more prominently when the teeth are in approximation and it is desired to exercise the maximum crushing force. It should be obvious that a lengthening of the vertical from one to five or six millimeters more than the normal will result in a traumatic derangement of the articulation of the artificial teeth and will contribute to the temporomandibular arthrosis syndrome, particularly in cases where the natural teeth had been greatly worn and the musculature is heavy.

A further suggestion is, that artificial teeth should be arranged initially with the mandibular central incisor. This should in a measure, assure the proper location of the mandibular first molar in its place as a key to functional occlusion.[7] To equalize and perfect the articulation the teeth at the "try in" stage should be caught in plaster and remounted on the articulator. When vertocclusion has been correctly secured this measure will minimize spot grinding.

REMARKS

At this midcentury period, the future, as it pertains to the use of denture adhesives, indicates their use will be continuous.

Atrophic changes in the tissues supporting dentures are accelerated by osteomalacic diseases which hasten the use of adhesives.

The vertical location of the combined occlusal plane and the vertical dimension, termed vertocclusion in this paper, is fixed by the eruption of the mandibular and maxillary first molars and remains invariable throughout life. Its vertical component only, varies, because of atrophic changes in the mandibular and maxillary processes when teeth are absent or present. When teeth are lost in these atrophied bone cases the vertical dimension should be recaptured from measurements taken from between the increased heights of the resorbed ridge crests at the median line of both processes. The integrity of vertocclusion and the vertical dimension, should be maintained.

Most technical blunders are made at the chair while vertocclusion is in the process of integration. No suitable instrument or caliper for the accurate measurement of the vertical dimension is available at dental supply depots.

The term, "registering centric," lends ambiguity to any course taken toward its integration. This uncertainty ranges from biting into fickle wax, to recording it with precision.

To obviate this misleading term and to secure a clear development of centric it would be more explicit to transpose the word "registering" from "centric" to read, "registering the vertical."

When the vertical dimension is referred to for descriptive purposes its length in millimeters should be included in its description.

The line of the occlusal plane should intersect the vertical at a predetermined point at a right angle to it. The two are actually one integrated unit, which should be designated vertocclusion.

The maxillary occlusion rim should conform to this plane and should be carefully equalized before its mandibular component is formed against it.

Care in establishing the vertocclusal plane will facilitate the recording of centric. Its horizontal and vertical location can then be oriented with pinpoint accuracy.

To hazard a guess as to the proper length of the vertical dimension and the exact location of centric tends toward excessive spot grinding and the consequent use of adhesives.

At the present time full denture prosthesis is not at its highest standard. It may be feasible to work out a simple system of standardized technique that will be acceptable to colleges—a system that will yield results beyond present-day accomplishments.

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AN EFFECTIVE PATTERN OF OCCLUSION IN COMPLETE ARTIFICIAL DENTURES

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THE benefits of a balanced occlusion are generally recognized. However, wide disagreement exists as to the nature and requisites of such an occlusion in complete artificial dentures.

The proponents of the different schemes offer varying explanations to support their theories of prosthetic occlusion. The confusion thus created merely adds to the general practitioner's dilemma.

A basic knowledge of the anatomy, the possession of a thorough and definite concept of the physiology of mastication, and some degree of familiarity with the techniques presently employed and advocated would better enable the operator to make a more intelligent evaluation of the problem.

With that as a background, a decision on a pattern of occlusion should be made. The plan of choice should provide maximum chewing efficiency, without sacrificing any of the factors vital to denture retention and stability, and with due regard for the preservation of the health of the supporting structures.

A brief description of the masticatory cycle in a well-balanced natural dentition will help to clarify the discussion. In the initial protrusive act of prehension and incision, the mandible is depressed, with the condyle heads moving downward and forward along their inclined paths, primarily, through the bilateral action of the external pterygoids assisted by the anterior fibers of the temporal muscle.[1] In the next phase of the chewing cycle, the mandible is again depressed and swung into the right terminal lateral position for the crushing stroke, if the bolus of food is on the right side. Simultaneously, the left condyle moves downward, forward, and inward, while the right condyle merely rotates except for the Bennett movement. The lateral movement is initiated by the external pterygoids; the crushing stroke, by the combined elevating action of the masseter, temporal, and internal pterygoid muscles. After the food is penetrated, the mandibular denture is carried across the maxillary teeth to the centric relation position. This mandibular side shift is now assisted by the contraction of the right internal pterygoid muscle, the condyles retracing their original paths into the eccentric positions.[1, 2] From the centric position the mandible is then swung across to the opposite terminal lateral position while the balancing cusps and teeth on the active side are engaged in the most effective shearing of the entire masticatory cycle.[3] The mandible is then depressed again for a repetition of the crushing and shearing action just described. During the swing from the eccentric to the centric position and then

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to the opposite lateral position, the food is trapped, pierced, and shredded by the sliding convexities of the teeth.[4] The points at the peaks of the convexities do the cutting. These cusp points will function effectively against opposing surfaces, whether they be flat, concave, or convex.[5, 6] During the entire chewing procedure, relegation of the bolus of food to the masticatory table is accomplished through the combined action of the tongue and the orbicularis oris muscle anteriorly and the buccinator laterally.[7, 8] The importance of keeping the occlusal plane below the normal rest level position of the tongue and in correct relationship to the level of the inward bellying of the buccinator muscle,[9] to facilitate the redeposition of the food on the masticatory table after each biting action, is therefore obvious. Too high a plane would not only jeopardize the retention and stability of the denture, but would grossly impair masticatory efficiency as well.

At this point some of the techniques and schemes of occlusion more generally advocated may be considered.

A brief recapitulation of some of the oft repeated failings of the spherical theory will suffice. Reliable observation has shown repeatedly that although the occlusal surfaces of the lower teeth may appear to conform to the segment of an eight-inch sphere, the teeth definitely do not move along the surface of such a sphere. The contention that the movements of the mandible will readily adapt themselves to this pattern of occlusion is fallacious since the condyles are generally inadaptable.[2] The disharmonies introduced in such an occlusion would exert a deleterious effect on the underlying bone and tissue supports. Individual antero-posterior and lateral movements are not encompassed within the spherical machine, nor are the tooth forms advocated found to exist in nature.[10] According to Russell C. Wheeler,[11] "Nothing anatomic may be reduced to the mathematical exactitude of geometrical terms."

The undue prominence of the mandibular buccal cusp evidenced in the spherical scheme, attendant with its introduction of undesirable resultant forces, led to the advocacy of the so-called anti-Monson curve, espoused first by the Avery brothers and subsequently, with modifications, by Pleasure.[12] Nonanatomic teeth with a downward lateral pitch are utilized by the latter in this scheme of occlusion. These teeth are further modified by grinding the buccal half of the lower occlusal surfaces and the lingual half of the upper occlusal surfaces. Cutting efficiency must of necessity be sharply curtailed thereby. Generally, flat teeth and teeth that have been synthesized to simulate wear are dull and do not cut effectively.[5] With flat teeth or teeth so created there is a loss in cutting efficiency of the occlusal surface that is directly proportional to the extent of the deterioration of that surface.[6] The greater the number of cusps and surfaces in contact, the greater the crushing and triturating efficiency of the dentures regardless of whether they be natural or artificial. Clinically, a balanced occlusion with maximum contact throughout the entire range of functional jaw movements is difficult to attain with flattened teeth.[13, 14] The anti-Monson curve is reversed by Pleasure in the second molar region to provide for but one balancing contact on the inactive side when the intermaxillary pressures are greatest during the last phase of adduction. This curve would admittedly tend to stabilize the lower at the expense of the upper,

although quite frequently the upper denture may be the less stable member. According to Pleasure, the additional increase in muscular activity attending the use of teeth of narrow buccolingual diameter might tend to unseat the dentures.[12] If that be true, identical undesirable consequences might very well ensue with the use of flat, dulled teeth. Utilization of this type of occlusion would deny the patient the most effective shearing by the so-called balancing cusps on the working side, thus impairing chewing efficiency. The excessive forces required with dull teeth not only induce more rapid muscular fatigue but also traumatize the underlying bone and tissue supports.

In still other procedures, the use of flat teeth and a flat plane of occlusion are recommended, dispensing entirely with the reverse pitch and/or balancing contact in the second molar region. Since the condyles usually do not travel in a horizontal path,[15] the dentures in such cases would be out of occlusion on the balancing side, even though the resiliency of the tissues might conceal these discrepancies.

The functional bite technique, with its widely heralded notion that there is no better articulator than the mouth, has achieved some degree of recognition from the profession. The functional centric, however, is generally not the true centric position. In the natural dentition various factors, such as occlusal wear, loss of teeth with its attendant evils, namely shifting and drifting, and defective dental restorations, may have contributed to the development of a deranged masticatory mechanism. These prevailing disharmonies in the occlusion have instigated the habit of chewing in an eccentric relation and the acquisition of a functional centric position. When chewing resistant food with artificial dentures, however, the mandible will be thrust into its most retruded position by the muscles of mastication, since with the removal of the remaining natural teeth the barriers to a return to the true centric position will have automatically been eliminated. Failure to incorporate the true centric relation in artificial dentures is an invitation to disaster and a major contributing factor to the premature destruction of the underlying bone and tissue supports. Retention and stability are endangered and chewing efficiency interfered with.

Due cognizance should be taken of Swenson's keen evaluation of the mouth as an articulator. His comments merit repetition.[16] According to Swenson, "The mouth does not afford visibility to properly position and examine the teeth; the resiliency of the tissue precludes constant equalization of pressure in various denture positions; the denture bases shift under incline plane stress without the operator being aware of it, whereas on a stone cast, this cannot happen; the temporomandibular joint can be malpositioned since no repeated checks are possible; and lastly, an exact centric can be obtained and transferred to the articulator which assures an exact and correct starting point for each movement. This correct starting point in the mouth is not controllable."

In techniques stressing the rebalancing of completed dentures directly in the mouth, the difficulties bound to be encountered in obtaining equalized pressure in the various denture positions would be manifested in the final result by the introduction of premature contacts with resultant disharmonies on the one side and

lack of balancing contacts on the opposite side. With a great many patients much effort and energy is required merely to obtain a correct centric relation for the purpose of transferring this record to the articulator. A lengthy rebalancing procedure performed directly in the mouth, which must of necessity repeatedly include the correct starting position, will tend to deplete both patient and operator of considerable physical and nervous energy. This factor merits more than passing consideration.

Still other techniques advocate the fabrication of complete dentures to arbitrary design without due regard for individual anatomic variations. These can be summarily dismissed in the words of E. C. Pendleton,[17] "If the characteristics of the musculature influence denture design, they likewise preclude all possibility of contouring the prosthesis according to a standard pattern. Individuality of the muscle attachments, their movements as affected by the investing tissues and habits acquired by the individual complete a cycle of conditions making of each case a distinct or separate problem."

Regardless of the choice of the pattern of occlusion or the technique employed, the construction of a set of complete dentures resting upon a foundation of unevenly yielding supports must of necessity involve periodic check-ups for the purpose of correcting any subsequent changes in the occlusion and the centric relation. The various factors associated with individual bone and tissue changes and esthetic requirements will determine the need for ultimate replacement of the old dentures by new ones.

It was previously indicated that effective cutting of food is accomplished by a moving contact point[5] functioning against an opposing incline, either flat, convex, or concave.

A plan of occlusion predicated upon this concept in conformity with the natural chewing habits and incorporating Schuyler's ideals of occlusal harmony will assure the realization of the objective originally declared, namely, maximum chewing efficiency, and yet with every safeguard for maximum retention and stability and the preservation of the health of the supporting foundations.

The ideals of occlusal harmony as published by Schuyler[18] are:

1. Maximum distribution of stress in centric maxillo-mandibular relation.
2. Retention of the maxillo-mandibular opening.
3. Harmony of guiding inclines, thereby distributing eccentric occlusal stresses.
4. Reduction of the incline of guiding tooth surfaces, that occlusal stresses may be more favorably applied to the supporting tissues.
5. Retention of sharpness of cutting cusps.
6. Increase of food exits.
7. Decrease of contact surfaces.

A definite systematic procedure of selective grinding[16, 19] is essential in fulfilling these ideals and in endeavoring to achieve full cuspal coordination throughout the entire range of functional jaw movements.[3] Success with any plan must be based among other factors upon such cardinal considerations as a careful impression technique, incorporation of the correct centric relation, avoidance of ex-

cessive leverages in the development of a well-balanced occlusion, and proper orientation of the casts on a good articulator.

In the impression technique, utilization of the maximum bearing area without undue displacement of tissue and adequate provision for resistant areas is fundamental. The principle of extension into the sublingual space within the limits of physiologic tolerance to augment retention and stability is advisable.

The centric relation position can be recorded with either the gothic arch tracing or with interocclusal wax check bites. Where disparity in the ridge relation exists, with uneven distribution of soft tissue over the ridge areas, an unstrained maxillo-mandibular relationship is better secured with the wax check bites. Trapozzano,[20] in a recent publication, and previously in conjunction with Schuyler and Swenson, has furnished evidence to indicate that wax check bites, when properly handled, particularly in the type of case just mentioned, afford better equalization of pressure than can be obtained with the gothic arch tracing.

Although the need for incorporating the correct centric relation is universally acknowledged, the reasons therefor are not generally understood. The centric relation position represents the center of muscle pull. It is the position associated with the function of mastication. When chewing lightly, either a functional protrusive or lateral position or a combination of both is used.[21] When resistant food is encountered, however, the muscles of mastication will catapult the mandible into its most retruded position. Failure to record the correct centric relation will invite premature contacts, with resultant instability, discomfort, resorption and soreness.

In ascertaining the true centric relation the physiologic rest position should first be determined in order to make provision for an adequate free-way space. The technique for this procedure which is of prime importance is fully discussed in the literature.[22-25] Excessive opening or closing of the vertical dimension must be avoided. An excessive increase may induce premature destruction of the ridges, interference with speech and mastication, clattering of the dentures, and the production of a strained facial appearance. Upon biting pressure, the divergence of the ridges anteriorly might precipitate a forward displacement of the dentures. Excessive overclosure, according to Sicher,[26] may destroy the balance between the condyle and disc relation, instigating destruction of the discs and the onset of an osteo-arthritis deformans. Overclosure reduces the size of the denture space. The tongue may be displaced posteriorly, encroaching upon the adjacent tissues and interfering with throat function. Esthetically it may produce a collapsed appearance of the lower third of the face. La Perlèche or angular cheiliosis may be the direct result of an excessive overclosure. Temporomandibular disturbances and discomfort may arise from either excessive increase or excessive decrease of the denture space.

Harmony of movement must be created on the articulator (Hanau model H). The guiding inclines of the cusps of the teeth must be in harmony with each other and with the condylar incline posteriorly and the incisal path anteriorly. The condylar guidance controlling the posterior movements of the mandible is furnished by the patient's protrusive record. The incisal guidance is arbitrary and is determined by the operator.

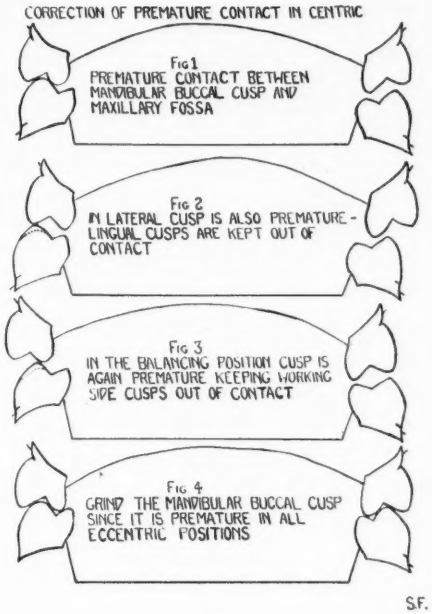
CORRECTION OF PREMATURE CONTACT IN CENTRIC
FIG 1
PREMATURE CONTACT BETWEEN MANDIBULAR BUCCAL CUSP AND MAXILLARY FOSSA
FIG 2
IN LATERAL CUSP IS ALSO PREMATURE - LINGUAL CUSPS ARE KEPT OUT OF CONTACT
FIG 3
IN THE BALANCING POSITION CUSP IS AGAIN PREMATURE KEEPING WORKING SIDE CUSPS OUT OF CONTACT
FIG 4
GRIND THE MANDIBULAR BUCCAL CUSP SINCE IT IS PREMATURE IN ALL ECCENTRIC POSITIONS
S.F.

Fig. 1.

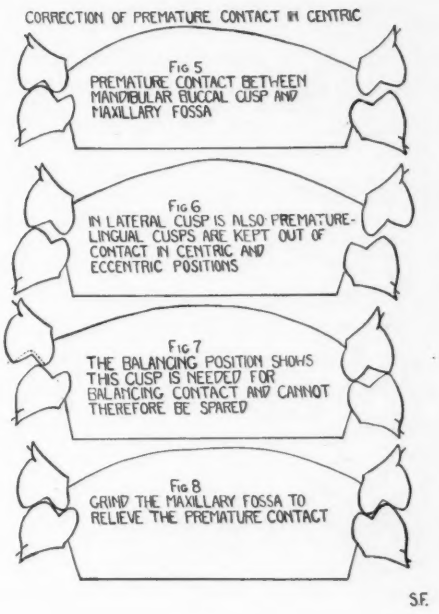
CORRECTION OF PREMATURE CONTACT IN CENTRIC
FIG 5
PREMATURE CONTACT BETWEEN MANDIBULAR BUCCAL CUSP AND MAXILLARY FOSSA
FIG 6
IN LATERAL CUSP IS ALSO PREMATURE - LINGUAL CUSPS ARE KEPT OUT OF CONTACT IN CENTRIC AND ECCENTRIC POSITIONS
FIG 7
THE BALANCING POSITION SHOWS THIS CUSP IS NEEDED FOR BALANCING CONTACT AND CANNOT THEREFORE BE SPARED
FIG 8
GRIND THE MAXILLARY FOSSA TO RELIEVE THE PREMATURE CONTACT
S.F.

Fig. 2.

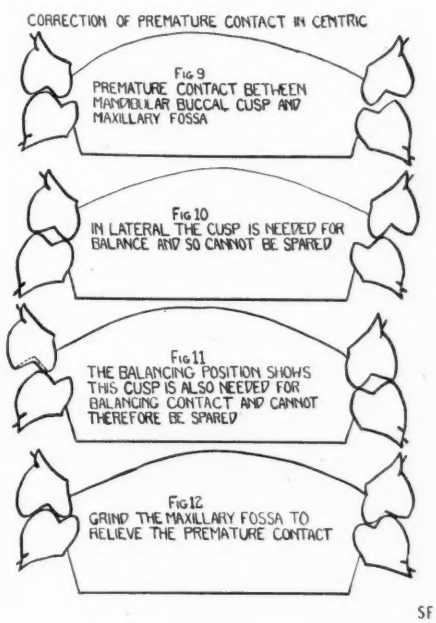
CORRECTION OF PREMATURE CONTACT IN CENTRIC
FIG 9
PREMATURE CONTACT BETWEEN MANDIBULAR BUCCAL CUSP AND MAXILLARY FOSSA
FIG 10
IN LATERAL THE CUSP IS NEEDED FOR BALANCE AND SO CANNOT BE SPARED
FIG 11
THE BALANCING POSITION SHOWS THIS CUSP IS ALSO NEEDED FOR BALANCING CONTACT AND CANNOT THEREFORE BE SPARED
FIG 12
GRIND THE MAXILLARY FOSSA TO RELIEVE THE PREMATURE CONTACT
SF

Fig. 3.

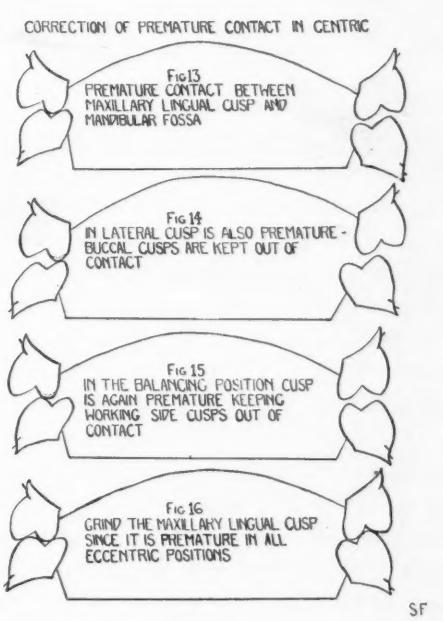
CORRECTION OF PREMATURE CONTACT IN CENTRIC
FIG 13
PREMATURE CONTACT BETWEEN MAXILLARY LINGUAL CUSP AND MANDIBULAR FOSSA
FIG 14
IN LATERAL CUSP IS ALSO PREMATURE - BUCCAL CUSPS ARE KEPT OUT OF CONTACT
FIG 15
IN THE BALANCING POSITION CUSP IS AGAIN PREMATURE KEEPING WORKING SIDE CUSPS OUT OF CONTACT
FIG 16
GRIND THE MAXILLARY LINGUAL CUSP SINCE IT IS PREMATURE IN ALL ECCENTRIC POSITIONS
SF

Fig. 4.

Figs. 1 to 4.—Graphic illustration of the method of grinding for correction of some of the more common prematurities encountered in the centric and eccentric positions. (Grinding procedure as suggested by Schuyler.[18])

Diagrams are fashioned after those in Merrill G. Swenson's textbook entitled "Complete Dentures."

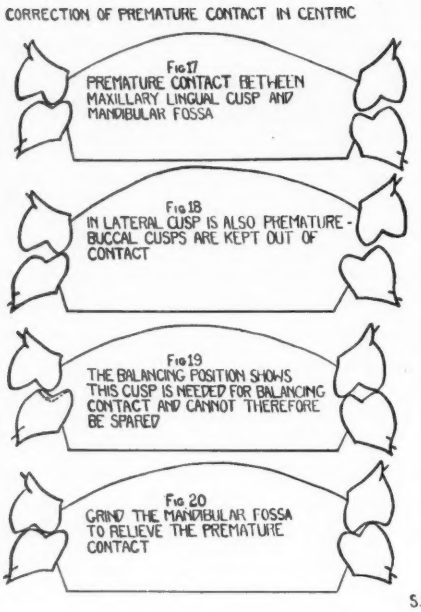
CORRECTION OF PREMATURE CONTACT IN CENTRIC
Fig 17
PREMATURE CONTACT BETWEEN MAXILLARY LINGUAL CUSP AND MANDIBULAR FOSSA
Fig 18
IN LATERAL CUSP IS ALSO PREMATURE - BUCCAL CUSPS ARE KEPT OUT OF CONTACT
Fig 19
THE BALANCING POSITION SHOWS THIS CUSP IS NEEDED FOR BALANCING CONTACT AND CANNOT THEREFORE BE SPARED
Fig 20
GRIND THE MANDIBULAR FOSSA TO RELIEVE THE PREMATURE CONTACT
S.F

Fig. 5.

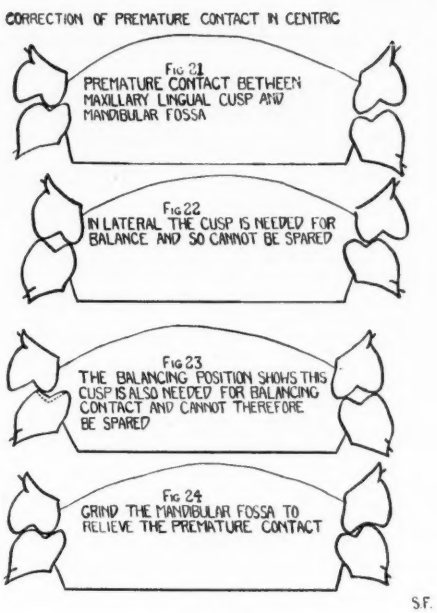
CORRECTION OF PREMATURE CONTACT IN CENTRIC
Fig 21
PREMATURE CONTACT BETWEEN MAXILLARY LINGUAL CUSP AND MANDIBULAR FOSSA
Fig 22
IN LATERAL THE CUSP IS NEEDED FOR BALANCE AND SO CANNOT BE SPARED
Fig 23
THE BALANCING POSITION SHOWS THIS CUSP IS ALSO NEEDED FOR BALANCING CONTACT AND CANNOT THEREFORE BE SPARED
Fig 24
GRIND THE MANDIBULAR FOSSA TO RELIEVE THE PREMATURE CONTACT
S.F.

Fig. 6.

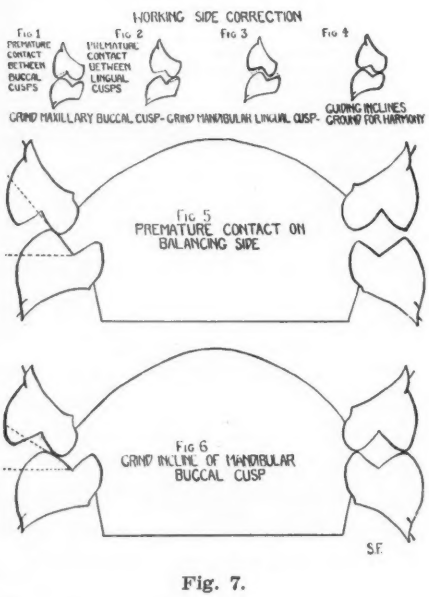

Fig. 7.

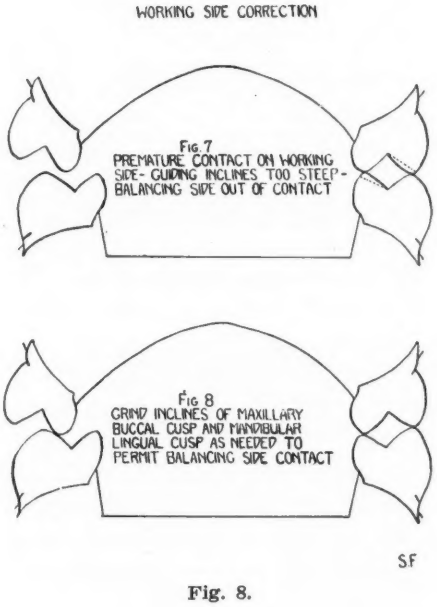
WORKING SIDE CORRECTION
Fig. 7
PREMATURE CONTACT ON WORKING SIDE - GUIDING INCLINES TOO STEEP - BALANCING SIDE OUT OF CONTACT
Fig 8
GRIND INCLINES OF MAXILLARY BUCCAL CUSP AND MANDIBULAR LINGUAL CUSP AS NEEDED TO PERMIT BALANCING SIDE CONTACT
S.F

Fig. 8.

Figs. 5 to 8.—Graphic illustration of the method of grinding for correction of some of the more common prematurities encountered in the centric and eccentric positions. (Grinding procedures as suggested by Schuyler.[18])

Diagrams are fashioned after those in Merrill G. Swenson's textbook entitled "Complete Dentures."

Since a flat incisal guidance automatically will furnish inclines that are less steep and since stability is enhanced by more shallow inclines, that is the guidance of choice in practically all cases. Occasionally esthetic requirements, prominent ridges, disparity in the ridge relation or inadequate denture space may indicate the need for a steeper incisal guidance.

The face-bow is an invaluable aid in establishing occlusal harmony, besides recording the position of the maxilla with reference to the opening axis.

In the development of the pattern of occlusion, due care must be exercised to avoid the introduction of excessive leverages. The denture space should be studied carefully and a plane of orientation selected with this factor in mind. Unfavorable leverages will be created if the arrangement of the posterior arch is too wide or the maxillary buccal cusps have too marked an inclination. The lower anteriors should be set neither too far labially nor too far lingually, since in the first instance lip action might tend to displace the denture posteriorly, whereas, in the second instance, tongue action might induce displacement anteriorly. The occlusal plane should be slightly below the level of the dorsum of the tongue when in the rest position.

The evaluation of the tongue position as an important factor in the ability of the patient to master the chewing of food with artificial dentures has been brought to light only recently. According to Wright,[27] the so-called retracted or clumsy tongue was found in about 30 per cent of a series of cases studied. The patient's adjustment to dentures is believed to be retarded by the presence of the abnormal tongue position.

The thirty-three degree posterior anatomic tooth is used because even after modification by grinding it will best fulfill the ideals and objectives previously outlined. The teeth are altered by a definite procedure of selective grinding to conform to the arc of movement created on the articulator. The contour and steepness of the cusps is determined on the working side by the lateral inclines of the glenoid fossa and the incisal guidance anteriorly; on the balancing side by the anteroposterior inclines and the incisal path. The objectives and ideals previously mentioned are attained by a systematic procedure of selective grinding and careful adherence to the technique.[23] This procedure will insure the development of an efficient masticatory apparatus with the elimination of the steep objectionable inclines usually associated with anatomic teeth.

All processed dentures are remounted for the correction of prematurities in the centric and eccentric relations. Where the casts have been grooved prior to curing, the dentures with their respective casts can be remounted to their original positions on the articulator, thus assuring greater accuracy. They can then be balanced with a minimum loss of chair time. It is deemed best to process one case at a time. The upper denture is completed first, remounted, and the lower teeth reset while still in the wax. If, for some reason, this procedure has not been utilized, then a plaster index should be made of the occlusal surfaces of the upper teeth while in the wax. The completed upper denture is inserted into this index and remounted with plaster to the upper member of the machine. With both completed dentures replaced in the mouth, a new centric relation record is taken using

two layers of softened wax over the dried occlusal surfaces of the lower denture. Premature contacts in the wax must be avoided to insure an unstrained record. The lower denture is then remounted on the articulator. The dentures are again replaced in the mouth and a new centric relation record made to prove the mounting. The bite and its mounting must coincide to prove the correctness of the centric contact. It is advisable that a new unstrained protrusive record be made, using three or four layers of wax. The articulator is adjusted to the new readings.

The articulator, with the pin removed from the incisal table, is opened and closed several times, interposing thin articulating paper first on one side and then on the other to mark any premature contact. Each prematurity is tested in the eccentric positions in order to decide where to grind. Marking and grinding is continued, using mounted stones until practically all teeth contact in the centric position. If the cusp is premature in both centric and eccentric positions, the cusp is ground. If it is premature in the centric position only, the opposing fossa is ground. The anterior teeth present no problem as they are set out of contact.

The pin is now replaced and left in position while the grinding in of the eccentric positions is carried out. First one lateral position is done and then the other. The articulating paper is placed on one side and the machine moved into the working position. The articulating paper is then shifted to the opposite side and the same movement repeated. The working and balancing sides are thus marked. The marking and grinding is continued until the pin stays in contact with the incisal guide table in all lateral and intermediate movements. The buccal inclines of the mandibular lingual cusps and the lingual inclines of the maxillary buccal cusps are ground on the working side. On the balancing side it is advisable to reduce the premature contacts on the lower teeth only in order to preserve the upper lingual cusp. Anterior interference is eliminated by grinding the lingual surfaces of the upper teeth. The lower incisal edges can be ground, if necessary, to maintain esthetics. Very little grinding will be necessary for the protrusive position. Fine carborundum paste is then used to remove any irregularities in the porcelain while the pin remains in contact with the incisal table.

When properly ground in, the lower lingual cusps and the upper buccal cusps, constituting the posterior guiding inclines, will present almost flat surfaces. The sharpness of the upper lingual and the lower buccal cusps is retained. These cusps functioning against their opposing inclines retain the vertical dimension and do the cutting. In lateral movement the lower buccal cusp rides on the lingual incline of the upper buccal cusp and the upper lingual cusp rides on the buccal incline of the lower lingual cusp. The anterior guiding inclines are the lingual surfaces of the upper teeth. All flattened surfaces are then recut to insure adequate escapement spaces. All ground surfaces are repolished to permit free, smooth, gliding movements.

In elderly debilitated patients, in anemics and diabetics, in avitaminosis, in those with systemic illness and wherever the supporting alveolar bone is quite frail and the ridges extremely unfavorable, a reduction of the occlusal load, if indicated, is easily accomplished by the simple expedient of disoccluding and reshaping the mandibular buccal cusps of the bicuspids and first molars. Subocclusal sur-

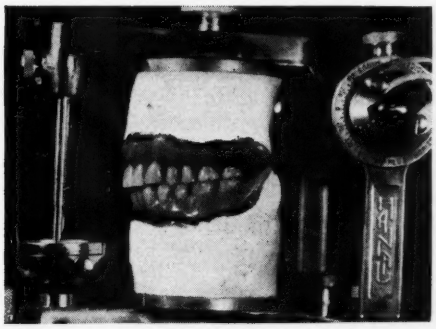

Fig. 9.—Centric occlusion.

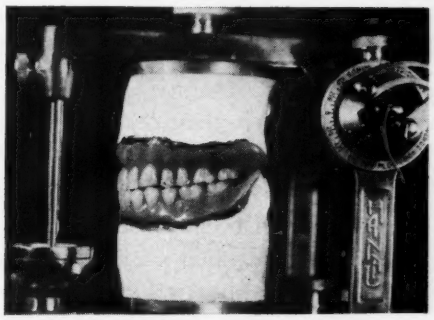

Fig. 10.—Protrusive position.

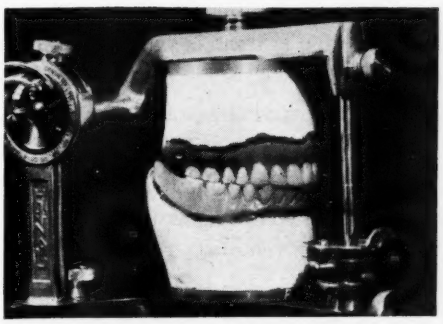

Fig. 11.—Right working position.

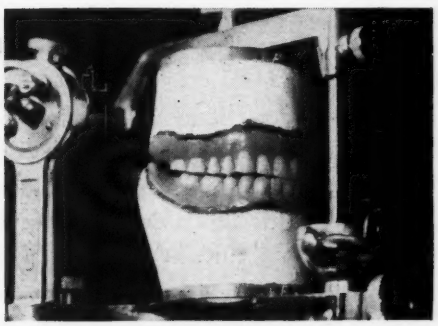

Fig. 12.—Right balancing position.

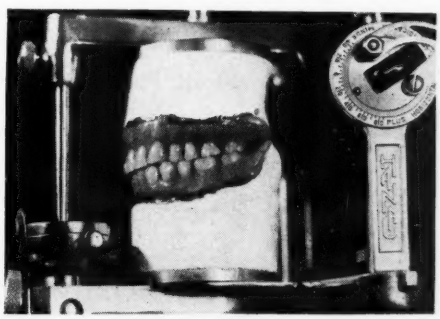

Fig. 13.—Left working position.

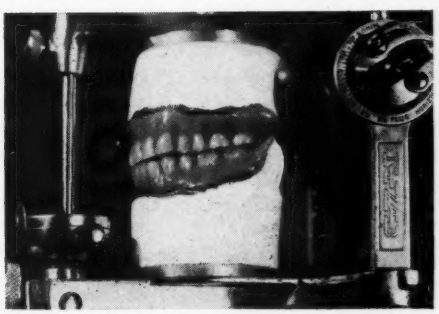

Fig. 14.—Left balancing position.

Figs. 9 to 14.—Photographs of mounted dentures after completion of grinding.

faces are created in the manner suggested by Sears.[29] The second molar balancing contact must be retained. The preservation of the maxillary lingual cusp functioning against the opposing buccal incline of the mandibular lingual cusp is of paramount importance for the maintenance of both maximum centric contact and adequate masticatory efficiency.

SUMMARY

An effective pattern of occlusion entails the need for varying occlusal alterations to insure conformity with individual functional requirements. Mounted diamond stones, where feasible, can be used to advantage to facilitate and expedite the technique. Successful, gratifying solution of the full denture problem demands a maximum effort. A minimum effort invariably yields a minimum result.

A scheme of occlusion carefully integrating the gnathodynamic factors of occlusion and based upon sound physiologic principles has been outlined.

The use of thirty-three degree posterior anatomic teeth providing maximum cusp and surface contact throughout the entire range of functional jaw movements will afford maximum masticatory efficiency.

Stability is enhanced by the proper positioning of the mandibular posteriors buccolingually so that a perpendicular dropped through the buccal cusps will bisect the crest of the ridge. The lingual position must not extend beyond the internal oblique line to avoid encroachment upon the tongue space.

Further protection is afforded the underlying bone and tissue supports through a reduction in the inclination of the guiding inclines.

Shallow but sharp cusp teeth functioning against smooth, harmonious inclines and developed through a definite procedure of selective grinding will furnish maximum masticatory efficiency without jeopardizing either retention or stability.

Correct centering of the entire occlusal load anteroposteriorly is essential.

Suitably selected anatomic teeth modified in the manner indicated will provide an adequate masticatory table, permit free mandibular movements and be highly esthetic in appearance.

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CORRESPONDENCE

An Effective Pattern of Occlusion in Complete Artificial Dentures, by Samuel Friedman, D.D.S.

Disclaimer

THE paper by Dr. Samuel Friedman purports to review the problems of denture occlusion in order to relieve the practitioner of the confusion created by contending theories. I am flattered to find that the author has included one of my papers in his bibliography, but somewhat distressed to be unable to accept either credit or responsibility for proposing the use of "flat, dulled teeth" as Dr. Friedman states.

To make certain that there is no ground for attributing such a recommendation to me, I have reread the paper referred to as number 12 in the bibliography and also another on the same subject published in October, 1938. In the paper cited by Dr. Friedman, an entire section is entitled "The Lower Teeth as Cutters;" in it one may find the following remarks: "The lower molars and bicuspids should have bucco-lingual ridges or cutting edges running parallel to the path of closure;" and "a sectorial type of tooth is more effective than a simple molar type." And in the next section: teeth "must possess a degree of cutting efficiency or sharpness that will decrease the pressure required to cut fibrous morsels and diminish traumatism of denture supporting tissues." This scarcely supports the belief that I recommend the use of flat teeth.

In his third paragraph Dr. Friedman observes that "the possession of a thorough and definite concept of the physiology of mastication . . . . would enable the operator to make a more intelligent evaluation of the problem." In heartiest agreement with this sentiment I am disappointed by his neglect to refer to the work of G. Y. Hildebrand, which has been abundantly confirmed by Kurth, Boswell, and, recently Jankelson, and which would, if he had studied it, have spared him from certain other misconceptions about the normal chewing cycle.

May I request that this disclaimer be published so the confusion which Dr. Friedman essayed to dispel may not be aggravated? Thank you.

M. A. Pleasure, D.D.S., M.S.P.H.
154 W. 71st Street
New York City

Feb. 21, 1951.

Reply to Dr. Pleasure

I HAVE the highest esteem for Dr. Pleasure's scientific contributions to dentistry.

I fully concur in his specifications that teeth "must possess a degree of cutting

Reprinted from the New York State Dental Journal 17:244, 1951.

efficiency or sharpness that will decrease the pressure required to cut fibrous morsels and diminish traumatism of denture supporting tissues."

In my article, Dr. Pleasure's technique of modification of non-anatomic teeth has been quoted almost verbatim from his paper "Prosthetic Occlusion: A Problem in Mechanics" (J.A.D.A. **24:**1303-1318, 1937). Then in a follow-up analysis of this procedure I wrote, "Cutting efficiency must, of necessity, be sharply curtailed thereby. Generally, flat teeth and teeth that have been synthesized to simulate wear are dull and do not cut effectively. With flat teeth or teeth so created, there is a loss in cutting efficiency of the occlusal surface that is directly proportional to the extent of the deterioration of that surface."

My subsequent reference to "flat, dulled teeth" is quite obviously, then, my *characterization* and evaluation of his use of non-anatomic teeth which have been subjected to the clinical modification procedures recommended by him.

Dr. Pleasure, in his article referred to above, says on page 1317: "Lacking teeth carved in accordance with the several stabilizing and cutting principles herein described, I have regularly employed Hall's teeth, after appropriate alteration, as the nearest available approximation."

The occlusal depressions in such inverted cusp teeth may tend to collect food. The more food trapped, the greater the chewing force required. Not only do excessive forces traumatize the underlying bone and tissue supports, but they also induce more rapid muscular fatigue.

It is quite evident, then, that the clinical treatment and modification procedures of the type of non-anatomic teeth actually used by Dr. Pleasure are the direct antithesis of, and at complete variance with his theoretical expositions on the subject. It doesn't seem likely, in my opinion, that his declared objectives of sharp cutting teeth can be thus attained.

I am not unfamiliar with the writings concerning the chewing cycle alluded to by Dr. Pleasure.

In the *New York State Dental Journal* (**15:**323, 1949), about twelve years after Hildebrand's publication in *The Journal of Dental Research* (**16:**551, 1937), Kurth, in an article entitled, "The Physiology of Mandibular Movement Related to Prosthodontia," wrote: "Knowledge of the physiological act of mastication related to the direction and extent of mandibular movement is incomplete. A study of past investigations of this movement reveals many conflicting theories."

Kurth acknowledges the existence of different points of view. I, too, fully realize the controversial nature of this subject. All statements in my article are substantiated by outstanding, recognized national leaders in the field. Apparently, another school of thought, acceptable among equally eminent authorities, is branded a "misconception" by Dr. Pleasure.

Respectfully submitted,
Samuel Friedman, D.D.S.
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March 5, 1951

BROKEN-STRESS PRINCIPLE AND DESIGN IN FIXED BRIDGE PROSTHESIS

MILES R. MARKLEY, D.D.S.

Denver, Colo.

IT IS generally accepted that fixed bridgework, where indicated, is more considerate of the supporting structures of abutment teeth, restores function better, and annoys the patient the least of all prosthetic appliances. Granger,[1] in discussing partial denture construction, has said, "Where indicated, a *fixed* bridge is always the restoration of choice."

Good fixed bridgework requires the most exacting of all restorative procedures. Fixed bridgework, by its rigid construction, creates stresses which tend to limit the useful life of the appliance, unless the engineering design compensates for the stress. Teeth joined rigidly together either must function as a unit, or the restoration will fail in one of three ways: (1) The least retentive attachment will be torn loose from its abutment tooth, and destructive caries will follow. (2) Some metallic portion of the bridge will fracture. (3) Frail parts of the bridge, such as porcelain facings or thimbles, will fracture due to continual flexing of the metal structure which supports them. Broken stress can help to prevent these three failures. It thus serves an entirely different purpose in fixed bridge prosthesis than in removable partial dentures, where broken stress is used to favor the periodontal attachments. We shall consider, first, the need for, and second, the methods of compensating for these destructive forces, together with other pertinent factors.

DENTISTRY OF THE PAST

Dentists of the past generation had little need for broken stress in fixed bridgework. The abutments they used were largely full-shell crowns, sometimes modified by a window in the labial surface. These crowns, by complete encirclement, grasped the teeth so securely that the entire bridge could be extracted with the abutment teeth attached. Alignment of the abutment preparations was of no serious consequence since the crowns fitted loosely everywhere except at the gingiva. Some of these crowns accurately restored tooth form, and gave many years of trouble-free service. An excellent example is an upper anterior bridge made in 1904 by Dr. William Shearer of Omaha. It replaced a previous bridge failure. The patient still wears fixed bridgework on the same teeth, which have now served as abutments for well over fifty years.

THE MODERN CONCEPT

Desire for improved esthetics through the years has stimulated changes in abutment design. Clamor for the inconspicuous has brought intricate and less

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retentive abutments into common use. In too many cases it has influenced dentists to attach bridges to inlays which hardly could be expected to serve alone as *single* restorations. An *unusual inlay* is required for a fixed bridge support.

The complete encirclement of a tooth remains as the strongest and most dependable abutment, and should be employed wherever possible. Complete gold crown coverage is indicated for all second and third molar abutments and on many lower first molar and second bicuspid abutments. For anterior abutments, porcelain or acrylic-veneered complete crowns provide the most retentive attachment, yet preserving esthetic values. As with shell crowns, broken stress is seldom needed with these strong attachments.

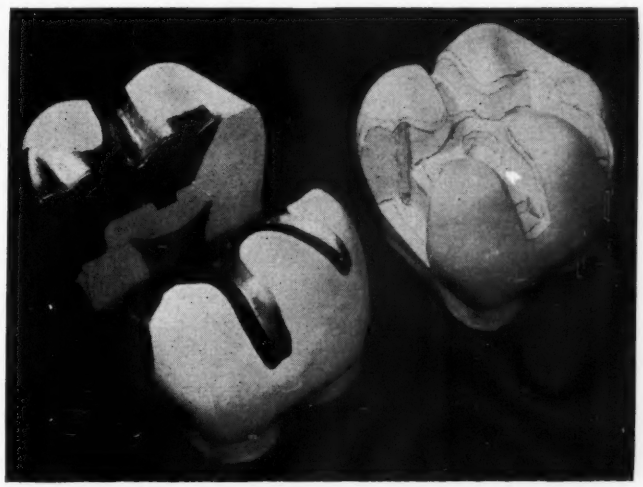

Fig. 1.—An *unusual* inlay is required for a fixed bridge support. This cavity preparation and inlay abutment casting will satisfactorily support the rigid end of a three-unit, broken-stress fixed bridge. Extensions through the buccal and lingual grooves serve as arms to stabilize the casting against rotational stress; at the same time they lock the tooth together against any tendency to fracture. The pin in the pulpal floor and the buccal and lingual grooves further stabilize the attachment against movement. If caries ever starts in the distal of the tooth, it can be filled without jeopardizing the bridge abutment.

If a stress-breaking mechanism *is* used, short posterior bridges can safely utilize the more esthetic and more conservative abutments. Three-quarter crowns, inlays of retentive design, and pinlays may provide satisfactory support (Fig. 1). With less strain, softer gold alloys can be used for abutment castings. It is the observation of many qualified operators that margins are less subject to failure when gold alloys with a Brinnell hardness of 80 or less are used.

WHY "BROKEN" STRESS

Each natural tooth is supported by a pericemental cushion which absorbs shocks and attaches the tooth to the alveolus. When stress is applied, each tooth moves within its particular range of attachment. Individual teeth vary in their movement depending upon: (1) the stress; (2) the length, breadth, and shape of their roots; (3) the long axis direction of the roots; (4) the alveolar bony support; (5) the thickness of the pericementum.

TWO ABUTMENT BRIDGES

Frequently a bridge is attached between one solid, sturdy tooth and a weaker member, such as between a second molar and a second bicuspid, to replace the missing six-year molar. In service, the smaller bicuspid abutment may develop a thicker pericemental cushion, compensating in a measure for the added stress applied against it. This abutment may now move more than the molar in function, and possibly in a different direction as well. This sets up terrific leverage strains tending to shear the cement bond on the weaker of the two attachments. All too frequently, destructive caries results before the loosening of the attachment is observed. Broken stress to the weaker attachment will dissipate much of the leverage force. Thus, a more esthetic abutment can be used safely, such as a well-anchored inlay, three-quarter crown, or pinlay, housing the stress breaker.

SHORT BRIDGES

Short bridges benefit more from broken stress than longer ones because:

1. Broken stress favors the light attachments which can be successfully used on short bridges only.

2. Conversely, broken stress is seldom needed with the heavy attachments which are necessary for long bridges.

3. Both abutments of a long bridge should share the torque load. Broken stress delivers most of the stress to the tooth which has the rigid attachment. This distribution varies to a degree dependent upon the type of stress breaker used.

4. A given amount of movement in abutment teeth delivers a more destructive force to a short bridge than to a long bridge. If the bicuspid abutment of the three-unit bridge just described has a hypothetical one millimeter of motion in function, that millimeter becomes the arc of a circle having a radius to the center of the molar abutment. If this were a four-unit bridge to the third molar instead, the radius would be longer, the arc described would be that of a larger circle, resulting in less rotational movement to pry the bicuspid attachment loose. Thus, it is the three-unit posterior bridges which almost universally benefit by broken stress, the longer ones less often. Short and long bridges might be compared to automobiles with short and long wheelbases being driven at a given speed. The short car gets the jolts.

LONG TWO-ABUTMENT BRIDGES

There is a notable exception which calls for broken stress on long two-abutment bridges. A new problem is presented when the long axes of the two abutments are at a wide variance (Fig. 2). In this situation, one abutment tooth attempts to move in one direction and the other in another when the patient bites. A failure was experienced with a five-unit bridge having a span from the upper cuspid to the second molar. The attachments consisted of a complete cast crown on the molar, and a three-quarter crown with added pin retention on the cuspid. The cuspid attachment was wrenched loose after two years. The reason: The long axes of the abutment teeth were at a wide variance. The molar crown was

inclined toward the distal, and the cuspid was strongly inclined toward the mesial. The problem was solved by constructing a new bridge with broken stress at the cuspid attachment. A semi-rigid box joint on the cuspid crown gave the cuspid a share of the torque, but allowed the abutment teeth freedom in their long axis movements.

THE ALIGNMENT PROBLEM

There is no such thing as *perfect* alignment, even in a two-abutment bridge. Many dentists place a bridge temporarily for a day or two, then cement it after this simple orthodontic procedure has relieved the strains of imperfection by moving the teeth. Broken stress helps to eliminate the mild discrepancy found in even a well-made bridge. This allows the bridge to be cemented safely as soon as it is finished. Thus, paralleling of abutment preparations becomes less critical with broken stress.

Fig. 2.—Stress is intensified by misalignment of an abutment tooth. Occlusal stress causes its long axis to move, shearing the attachment from its seat. This model also exemplifies the fact that an ordinary mesio-occluso-distal inlay makes a poor abutment, because one proximal seat acts as a fulcrum and the other as a lever in functional movement. Addition of occluso-lingual and occlusobuccal arms will greatly enhance the retention, as shown in Fig. 1. Broken stress will help to safeguard the abutment, but does not condone the use of weak design in fixed bridge supports.

MULTIPLE ABUTMENT BRIDGES

If a bridge has *more* than two abutments, satisfactory alignment is still more difficult to achieve. Broken stress simplifies the alignment problem, and neutralizes destructive forces.

In a long bridge span having three abutments, stress can be broken to either end, but should *not* be broken to the middle abutment. For example, in a second molar to second bicuspid to cuspid bridge, breaking the stress to the bicuspid would subject the relatively weak bicuspid abutment to extreme loads. Suppose that the patient bites on a piece of meat near the center of such a bridge. Practically all of the sixty-pound load will be carried by the bicuspid. If, however, the span is rigid through the middle attachment, the stress will be divided equally among the three abutments, each taking one-third of the load or twenty pounds. The same share-the-load factor holds in lateral stresses, which are even more

destructive to tooth-supporting structures than a vertical overload. It is imperative, however, that the middle attachment casting be very strong so as to resist flexing in every direction. If it flexes, the cement bond will soon be broken. A full crown or well-trussed hard gold three-quarter crown will serve, but *never* a mesio-occluso-distal inlay.

PONTIC DESIGN

Gabel teaches that the shape of any object is changed whenever stress is applied.[2] This is quite apparent in the function of a long fixed bridge. We have all seen the mysterious fracture of porcelain "sani-pontic" facings. Nothing could touch them, but yet they broke frequently and are now seldom used. Flexing of the pontic caused it. This flexing of the pontic also produces leverage which tends to break the attachments loose. Broken stress to the weaker abutment will protect *it,* but still the stronger one must tolerate the stress of flexing. Therefore, each pontic should be designed like a bridge truss and cast routinely in type "C" gold to keep flexing at a minimum. Such strength will also prevent pontic fracture.

ANTERIOR BRIDGES

Anterior bridges take less stress than posterior bridges for at least four reasons: (1) They function farther from the muscles of mastication. (2) A person chews many times on the posterior teeth to one bite on the anteriors. (3) Sharp incisal edges penetrate food with less pressure than is required in the crushing action of the molars and bicuspids. (4) The abutments function with a minimum of strain as a unit with the pontic because anterior abutment teeth are usually very nearly parallel. Therefore, broken stress is seldom necessary where abutments support both ends of an anterior bridge, and pinlays or three-quarter crowns will provide adequate anchorage for most cases. Even so, misalignment of anterior abutments may make broken stress advisable.

SIMPLE STRESS BREAKERS

The simplest form of broken stress is the rest of a wing bridge restoring an upper lateral incisor. Only in cases bearing great stress, such as a heavy end-to-end bite, do we need two abutments in this situation. However, a small rest to the unattached proximating tooth will check any tendency for the pontic to drift or rotate forward, and will reduce the leverage on the principal abutment. If it later proves to be one of those rare cases which drifts toward the lingual, the unnecessary rest can be easily removed. A round, wrought clasp wire is slightly flattened and contoured to the cingulum of the rest tooth. The pontic end is fluxed and a bit of solder is flowed over the end before it is waxed into the pattern. Casting to the fluxed solder brings complete union. A wrought rest has maximum strength with a minimum bulk to lodge caries-forming debris. The patient is charged with daily cleaning under the rest with dento-tape. In a mouth highly susceptible to caries or for an area of incipient caries, a gold foil filling is built with an indentation for the rest.

Another example for the use of a simple rest occurs where a posterior tooth has been lost, and drifting of the distal tooth has almost closed the space. The problem here is one of preventing food impaction, and correcting the force on the drifted tooth. Restoring the tooth will perfect occlusal harmony, but will increase the trauma caused by its tipped position unless a rest is placed to the forward tooth. Without the rest, occlusal pressure on the tipped molar causes a wedging action against the forward contact. A tremendous pressure is created by the principle of the inclined plane which results in periodontal injury. A rest to the marginal ridge of the forward tooth will change the resultant of force into one more favorable to dental health. Sometimes drifting will have left a very small space, and a tiny pontic with but one attachment and a rest will suffice.

MORE COMPLEX TYPES OF STRESS BREAKERS

In my early experience with broken stress I utilized either a heavy wrought wire pin in a tube or a dovetail rest. The pin prevented dislocation occlusally but not proximally. Although some of these have now been in service for as long as twenty years, no bridge has ever been lost through failure of the joint. The pin does not prevent mesial drifting of the forward abutment, and two cases that we see regularly threaten eventually to separate company of the pin from the tube. The dovetail cases have prevented distal and mesial dislocation, but unless locked with gold foil or a subsequently placed pin, they allow movement occlusally. Both methods have carried the load satisfactorily. These attachments, however, require that one abutment carry all of the torque load, and neither of them check motion in every direction adequately.

About eight years ago, Dr. E. E. Bailey,[3] of Denver, showed a stress breaker he had originated to a small study group. It answered the need so well that it has been used frequently ever since. The attachment consists of a box cut into the weaker abutment, usually roughed out in the abutment pattern, then perfected in the casting with burs. This box or female member has parallel walls and a gingival seat cut at a 45 degree angle to the occlusal plane. A pinhole is cut from the axial wall of the box into the occlusal step portion to a depth of about 2 millimeters, and parallel to the 45 degree gingival seat. Into this box or female member the pattern for the male portion is waxed, to be luted to the pontic pattern, then withdrawn and cast integrally with it (Fig. 3).

This broken-stress joint can be made of any size, shape, or strength depending upon the need. It transmits a major portion of the torque to the stress-broken abutment. It cannot be dislodged by any masticatory force. It prevents drifting in any direction. If either the fixed abutment or pontic fails, the pin can be severed with a bur through the occlusal surface, and the stress-broken abutment can be saved. Obviously the entire bridge must be cemented as a unit.

Another effective stress-breaking joint can be built by preparing an undercut cavity into the proximal portion of the abutment casting. The shape is preferably a triangle with rounded corners, with its base toward the gingival. The triangular cavity is lined with a paste of yellow ochre powder mixed with water, or other space-creating antiflux. Then the receptable is filled with wax which is

luted to the pontic. The pontic is cast, with the male portion attached, and in position in the female member. Although the degree of movement must be predetermined, and will vary by chance, Dr. Clay Withers, of Denver, has over a period of twenty years considered this a very satisfactory stress-breaker joint. It serves particularly well where space is limited, such as on the distal of a cuspid, or on any anterior tooth where broken stress is needed. Two precautions: The pontic with its stress lug should be cast into a cool mold, about 200° F., otherwise it will fit too tightly. Also, the wax, where the pontic joins the lug, must be trimmed back around the entrance to the receptacle before investing. Otherwise an impingement here may restrict normal movement of the broken-stress device.

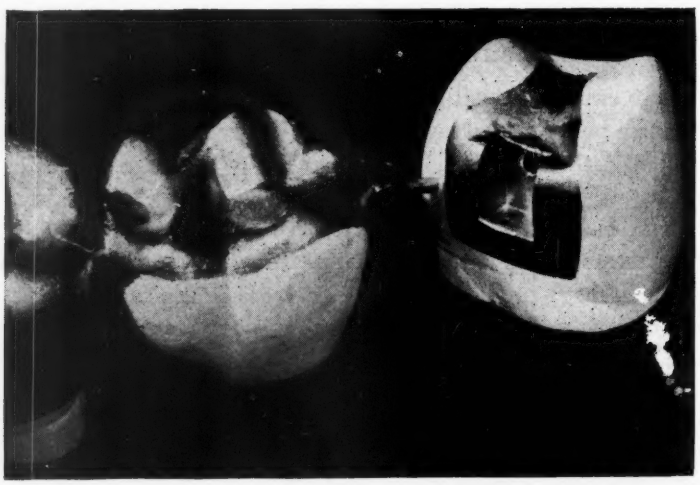

Fig. 3.—The Bailey type of broken-stress joint. Note that a rest type of solder joint is used at the rigid end of the bridge for greater strength. This aids in fitting the bridge in the mouth preparatory to soldering. An impression, over the occlusal portion of the joint which is to be soldered, is made with a thickly mixed lump of crown and bridge cement. It sets quickly. The two parts are assembled in the cement impression and waxed securely to it, then invested and soldered wh e the patient is still in the chair for a final trial fit, or delivery of the bridge.

The so-called "precision attachment" provides another effective stress breaker. With one end of the bridge soldered rigidly to its abutment, a precision attachment breaks the stress on the other end. Dislodgement is prevented by friction, by the natural lock in any direction except direct withdrawal, by slight riveting over the moveable portion, or by combination of any of the three.

Such a bridge can be cemented sectionally, the broken-stress abutment first. This is an excellent method for cases having the long axis of the abutment teeth at wide variance. No attempt need be made to align the abutment preparations. The precision attachment is itself built to parallel the abutment bearing the solid attachment. The stress breaker is placed on the most misaligned tooth regardless of its relative strength. Frequently a drifted second or third molar will house the stress breaker, with the solid joint on the weaker bicuspid abutment.

The precision attachment can be cast, cutting the T slot into the abutment, then waxing the T to the pontic pattern and casting integrally. It can be custom

made for the case at hand from clasp metal, as has been suggested by Dr. George Hollenback. Commercial precision attachments can be used.

SUMMARY

Broken-stress measures serve as "safety valves" against the tremendous leverage forces created by the rigid attachment to two or more teeth. The power of these forces was demonstrated by a recent experience where splints had been built to raise the bite on one side of the mouth to permit an orthodontic attempt to move molar teeth on the other side into functional occlusion. The three-tooth splint was cemented to the lower molar and bicuspid teeth on the left side. The cement bond failed, and the splint came off after one week. Subsequent cementation gave even less service. Then the splint was sawed through at each contact, and the several overlays thus created were cemented individually to place. They served without further loosening, and were removed only with difficulty at the end of the treatment period. The stress of the movement of one tooth prying against the others was eliminated much as a broken-stress joint frees a fixed bridge from destructive strain.

WHAT BROKEN STRESS DOES NOT DO

Broken stress should *not* be used to compensate such evils as occlusal imbalance, faulty abutment design, or overloading of abutments by broad pontic occlusal surfaces.[4] Broken stress will best serve as a safeguard in those places indicated only *after* the most favorable situation possible has been created by careful design and execution.

CONCLUSION

Demand for improved esthetics and conservatism in abutment preparation has brought radical change in fixed bridge abutment design. Clamor for the inconspicuous has brought intricate and less retentive abutments into common use. Clever engineering is required, else these pretty bridges and their conservative attachments bring loss rather than the preservation of the remaining natural teeth.

Broken stress, coupled with sound engineering and precision fit of abutments, can spell the difference between success and failure in many of these present-day restorations. Using these principles, lost and missing teeth can be restored comfortably and esthetically with fixed bridgework for periods of service exceeding that of any other prosthetic appliance.

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THE PROSTHETIC REPAIR OF DEFECTS OF THE MAXILLA RESULTING FROM SURGERY

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THE results of the study and practice of the prosthetic repair of defects of the maxilla resulting from surgery were strikingly shown in the treatment of the distressing deformities and disabilities resulting from war injuries during World War II. Previous to the war, patients who underwent maxillary surgery were generally left to suffer an unnecessary disfigurement, or if at a later date treatment was instituted, it was often long after the surgery had been performed. The dental surgeon was then faced with the correction of unnecessary disfigurement in the patient, the remaining parts having been distorted and pulled out of proper alignment and relationship by contraction of scar tissue and unbalanced muscle action; under such conditions, it was impossible to obtain ideal results. Much of this could have been prevented by timely action, splinting and so forth, before, during, or immediately after the surgery.

Kelsey-Fry,[1] in 1927, stressed the very great need of close cooperation between the surgeon and the dental prosthetist and the importance of a preoperative consultation to decide, as exactly as possible, the amount of tissue to be removed, which teeth (if any) were to remain, and so forth. The knowledge that cooperation between surgeon and dental prosthetist in such cases proved so beneficial during the war and that postoperative restoration was used so advantageously gives a further responsibility to the dental prosthetist who should offer his services to the surgeon to improve the results of the surgery and to enable the patient to enjoy a more comfortable existence.

Kazanjian[2] listed the causes of acquired deformities of the maxilla as (1) advanced stages of syphilis, (2) operations of malignant tumors, (3) tuberculosis, (4) necrosis caused by extensive inflammation of dental origin, (5) extensive fractures, and (6) gunshot wounds. He pointed out that destruction of the palate may vary in size, shape, and location, ranging from small perforations to total obliteration of the hard palate, and in many instances part or all of the soft palate may also be missing. He treats the simple perforation of the hard palate by merely covering the opening with the denture base, but where the opening is of considerable size, he not only makes use of any existing teeth for anchorage, but also extends the denture into the nasal cavity posteriorly. He described an ingenious arrangement for hinging the anterior extension so that the appli-

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ance could be more easily introduced. After it has been placed, the anterior attachment is swung back into position where it can be fastened or clipped in place. This appliance is similar to one described by Martin as illustrated by Pont.[3]

Pichler[4] discussed a vulcanite appliance used after maxillary resection. It is made in two parts, the upper hollow portion filling the space created by surgery and fitting lidlike into the lower portion or denture to which it is fastened, when in position, by a lateral hook. This arrangement facilitates insertion and removal.

Since deformities of this type present different problems, there can be no set rules for the construction or retention of an appliance. Some general factors should be considered nevertheless. It should be remembered that in cases of loss of tissue surgical replacements are always preferable to prosthetic restorations whenever possible and when they can be employed with good functional results. If, on the other hand, it is known that tissues *do* have to be removed, owing to disease, and *must* be replaced by mechanical means, appliances should be so designed and constructed that they will in no way cause irritation to the remaining soft tissues; especially is this true in cases of replacement made necessary by malignant disease. The restoration should be of as simple a design as possible and should be readily removable in order that it may be kept clean.

Following an operation, cavities formed by surgical removal are usually packed with gauze. Such packing, however, rarely prevents the tissues from falling in and becoming adherent. This causes a deformity in the face and the resultant difficulty of inserting a functional appliance later. To avoid these difficulties, temporary appliances are sometimes advised as soon after surgery as possible, and by their placement scarring and food contamination of the wound are greatly reduced. Later, a new denture may be constructed which merely occupies the remaining depression of the maxilla and holds the soft parts in their proper position, with the result that the contour of the face will not be altered and a functional denture may be supplied.

In any denture, the means of retention presents the greatest problem in construction. Retention may be provided by (1) natural teeth when present, (2) the remaining part of the hard palate, alveolar process, and buccal vestibules, and (3) the borders of the deformity and various surfaces of the nasal cavity. Thus cases where the defect is the result of surgery may be divided into three classifications: (1) those in which the individual is edentulous, (2) those where a portion of the teeth remain, and (3) those in which all or most of the maxillary teeth are in proper position and in a state of good repair.

A line of procedure for a case of the first class is described in the following: A 63-year-old, edentulous, white woman underwent a lateral rhinotomy with block resection of the left maxilla, performed to remove a carcinoma of the left maxillary sinus. The large cavity thus formed left an extensive opening between the alveolar process and the mucobuccal fold of the cheek, approximately 28 mm. long and 13 mm. wide, extending from the region of the left upper lateral incisor to that of the left upper first molar (Fig. 1). Immediately following surgery, this cavity was packed with gauze. A week later, an impression was taken of the mouth and defect in modeling compound and alginate impression material. This

was accomplished in the following manner. (1) A suitable tray was selected, one which incorporated all of the denture-bearing area, as well as the area of the defect. Into this was placed modeling compound which had been heated to the proper consistency. (2) This tray and compound were placed in the mouth with sufficient pressure to obtain an impression of the entire area without distortion of any of the tissues. (3) Just prior to the initial set of the compound, it was removed from the mouth, producing of necessity a considerable distortion of the material which had been forced into the defect. (4) This preliminary impression was thoroughly chilled and the entire palatal surface relieved by scraping it to a

Fig. 1.—Surgical defect communicating with oral and nasal cavities.

Fig. 2.—Finished impression for working cast of defect and maxilla.

depth equal to the thickness of the tissue covering the area. All undercuts were carefully removed; thus a compound tray of reasonable accuracy was developed. (5) The entire scraped surface of compound was flamed so that it became tacky, and cotton fibers were applied to this surface. (The compound should not be heated to the extent that it will be distorted in any manner during the placing of the cotton fibers.) (6) When this compound surface had become firm, alginate impression material was mixed and placed into the compound tray. Only enough

Fig. 3.

Fig. 4.

Fig. 3.—Clear acrylic bulb to be inserted into defect.

Fig. 4.—Finished denture looking from posterior aspect, showing the relation of bulb to tissue side of the palate.

alginate material was placed in the tray to compensate for the amount of compound previously removed. (If too much alginate material is placed in the tray, it will be forced down the patient's throat, causing gagging and discomfort, and around the peripheral borders, causing distortion in that area. If, on the other hand, an insufficient amount of alginate impression material is placed in the tray, voids will appear in the finished impression and an accurate reproduction will be impossible. Thus, it is important that care and judgment be exercised in placing the material into the compound tray.) (7) This compound tray with the alginate material was then inserted into the mouth, and an accurate impression was obtained of the maxilla and the defect (Fig. 2). (8) From the cast

obtained of this impression, a clear methyl methacrylate bulb was constructed which fit into the defect only (Fig. 3). This was placed into position, and another impression was taken in the same manner, thus furnishing an accurate relationship of the bulb and the remaining part of the hard palate. (9) Over the cast formed from this impression a template was constructed, which covered all of the available areas of the maxilla. On the tissue side of this, a circumscribed area, exactly the size of the bulb in the defect, was made through close adaptation of baseplate wax. This area was then channeled out with a round bur, and the bulb was fitted into the channel and processed into position. (10) Occlusion rims were formed, facial contour obtained, and centric relationship procured. (11) After appropriate teeth were selected and their arrangement checked, the denture was processed in the usual manner (Fig. 4). The denture was stable, had good retention, and gave the patient an excellent masticating surface (Fig. 5). Furthermore, there was no noticeable defect from all outward appearances (Figs. 6 and 7).

Fig. 5.—Denture in the patient's mouth.

A case of the second classification is illustrated by a 76-year-old white man with an adenocarcinoma of the maxilla. He was admitted to the hospital for surgery, and an attempt was made to retain the soft tissue of one-half of the palate (Fig. 8). Because of insufficient blood supply to the remaining tissue and lack of underlying bony support, necrosis and sloughing resulted, making removal of that tissue necessary (Fig. 9). This left a cavity 53 mm. long and 32 mm. wide which communicated directly with the nasopharnyx. The upper central incisor, lateral incisor, canine, first bicuspid, and second molar remained on the right side. The bony support around these remaining teeth was of such a nature that it would not have been wise to attempt to use them for retention of the prosthesis. Their removal was contraindicated because of previous irradiation to the mouth and the patient's general physical condition. A full upper impression was taken; the same technique was employed as that previously described. Particular attention was given to the area of the buccal vestibules above the re-

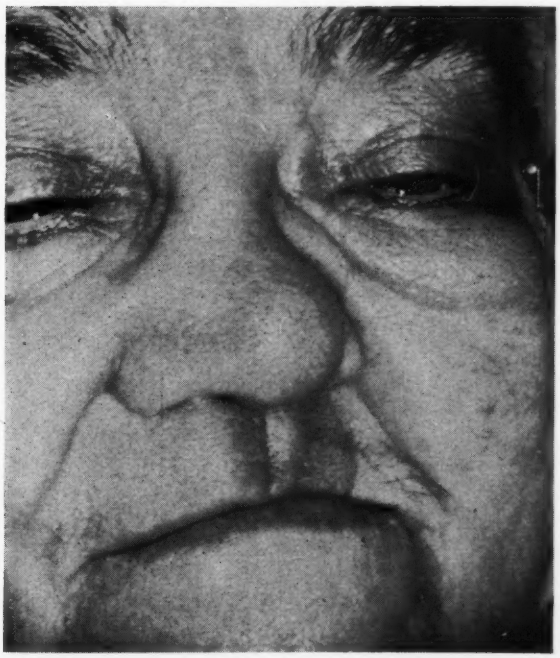

Fig. 6.—Facial contour without the denture. Note the depression below the ala of the nose on the left side.

Fig. 7.—Facial contour re-established by the insertion of denture.

maining teeth, since it was in this area that retention of the appliance was to be obtained. Over the resultant cast (Fig. 10), a bulb was constructed which fit the defect in the palate. An accurate impression of the entire surface of the maxilla was obtained with the bulb in position (Fig. 11). From this cast a template was constructed covering all of the palatal area, as well as the buccal vestibule. The bulb was sealed to the template in the same manner as was described in the case in the first class. The teeth selected were ground labially and cervically, stained, and set in such a manner that they simulated the remaining maxillary teeth.

Fig. 8.

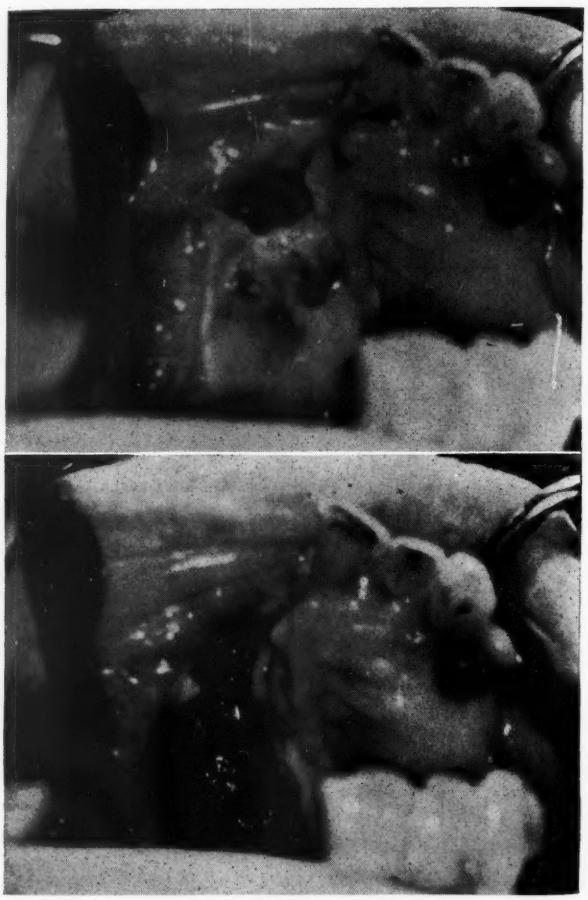

Fig. 9.

Fig. 8.—Necrotic soft tissue covering left portion of palate.

Fig. 9.—Cavity resulting from the removal of this tissue.

One change in the method of processing the finished denture was necessary in order to take advantage of the retention provided by the undercut areas above and around the remaining natural teeth. After the upper cast had been flasked and just before the acrylic material was packed, a strip of one thickness of base-

plate wax was placed on the buccal surface of the cast which extended from the cervical margins of the teeth to the reflection of the buccal mucous membrane of the cheek. This area extended from the right tuberosity to the right upper central incisor. The case was then packed in the usual manner with trial separations being made to ascertain that sufficient material was available to fill the mold. When this was certain, the wax strip was removed from the cast, and an amount

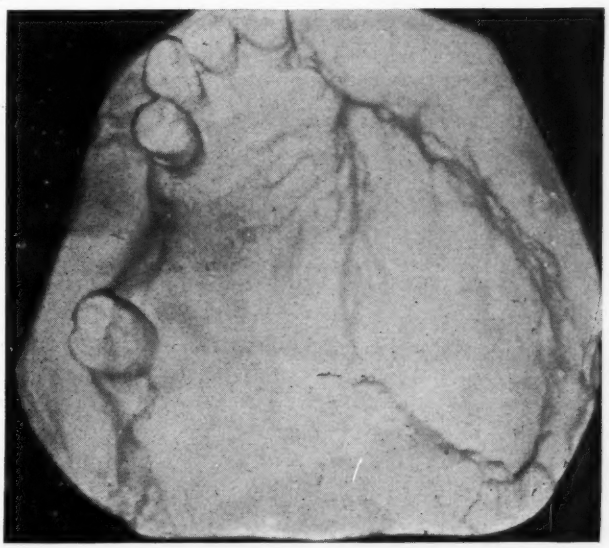

Fig. 10.—Working cast of maxilla and defect, showing undercut areas at mucobuccal fold to be used for retention.

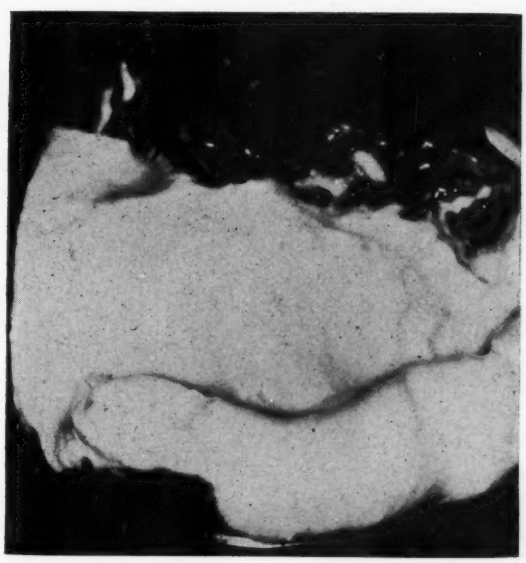

Fig. 11.—Impression of maxilla with bulb in position, giving accurate relationship of the two parts.

of soft plasticizing acrylic material equal to the thickness of the wax strip was placed in the void thus formed to complete the final packing. In this way, a definite thickness of soft material was obtained which would spring into the undercut areas without injuring the tissues. The palatal surface of the appliance is shown in Fig. 12, with the soft acrylic material at the peripheral borders. In Fig. 13 the denture may be seen in position in the mouth, completely closing off the communication between the oral and nasal cavities. The appliance then made it possible for this individual to masticate food and to talk with a reasonable de-

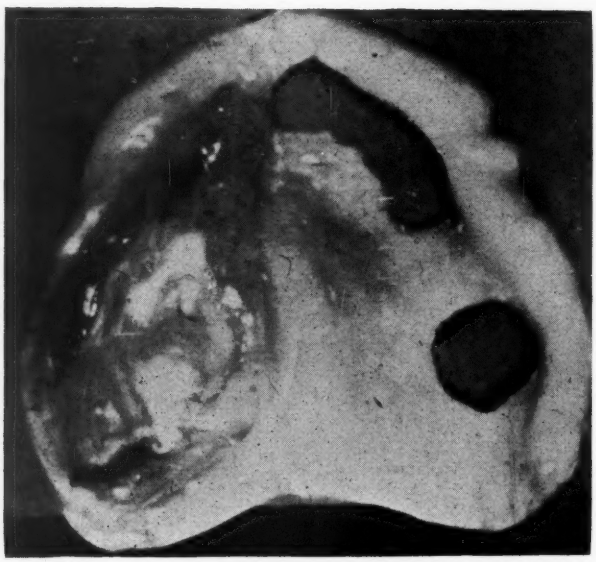

Fig. 12.—Soft acrylic material placed on buccal flange and peripheral border of denture.

Fig. 13.—Denture in position completely closing communication between the oral and nasal cavities.

gree of normalcy. Occlusion and esthetics were as good as could be hoped for, and there was no outward appearance of the defect (Fig. 14).

The third class may be portrayed by the following case: A white woman, 62 years old, with all of the natural teeth remaining and in good condition except the upper left first molar, came into the hospital with an adamantinoma of the left maxilla and nose. A lateral rhinotomy was performed; an opening was left into the oral cavity through the canine fossae extending from the midline approximately 5 cm. distally at the reflection of the buccal mucous membrane and the

Fig. 14.—Occlusion with denture in position. There is no outward appearance of the defect.

Fig. 15.—Cavity at mucobuccal fold. Natural teeth are in place.

buccal plate of the alveolus (Fig. 15). After excision of the tumor, a definite depression of the tissues of the cheek existed (Fig. 16). An impression of the cavity was taken in modeling compound immediately following surgery and before the patient left the operating room. In this way, it was possible to manipulate the compound in such a manner that the normal contour of the face could be re-established. The compound form thus developed was replaced by acrylic resin material. The second day following surgery, this acrylic form was inserted into the defect and an impression taken which included the protruding edge of the

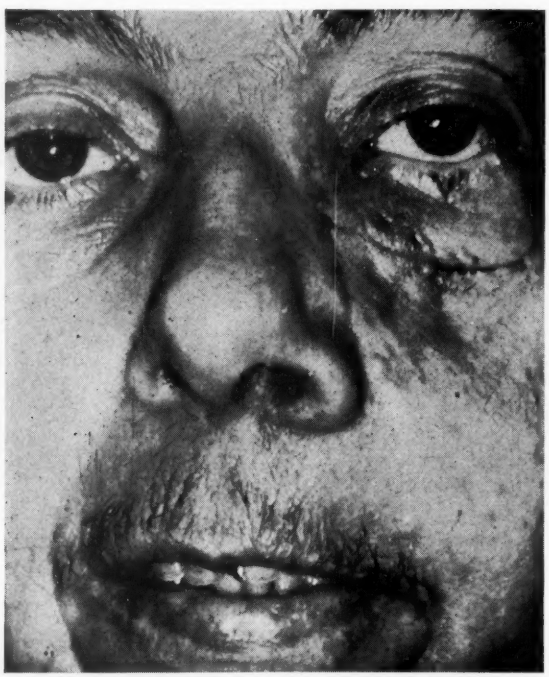

Fig. 16.—Facial contour without appliance on the second day following surgery.

Fig. 17.—Impression of the teeth and appliance for the construction of clasps.

plastic, as well as the teeth along that side of the arch (Fig. 17). From the cast formed by this impression (Fig. 18), clasps were constructed to fit the teeth selected for retention (Fig. 19). The prosthesis was then inserted into position (Fig. 20); thus the communication between the two cavities was closed off. Healing progressed normally with a noticeable lack of hard crust formation within the cavity proper. There was no adherence of the tissues, and a normal facial contour was re-established (Fig. 21). This prosthesis having been placed at an early date following surgery, foreign material was entirely excluded from the cavity.

Fig. 18.—Relationship of appliance to cast of teeth. Note the height of the appliance.

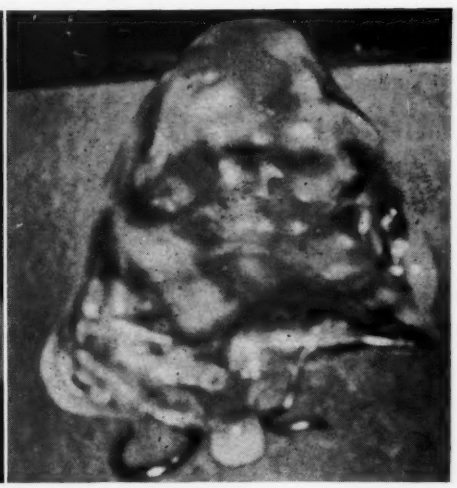

Fig. 19.—Finished appliance with clasps.

All three cases reported here have required appliances constructed to replace tissue lost through removal by surgery. This was accomplished with the closest cooperation between the department of surgery and the dental department. They are typical of the three classes of cases mentioned earlier: (1) cases in which the individual is edentulous, (2) cases in which a portion of the teeth are remaining, and (3) cases in which all of the maxillary teeth are in position and in a state of good repair.

Two cases which the writer has reported utilized the attached hollow bulb method, a method which in his hands has had exceedingly good results. The advantages of such a procedure seem clear. (1) The considerably reduced weight of the finished appliance as compared to other types favors proper retention. (2) The great amount of elasticity usually present in the remaining tissue makes for ease of insertion and removal and eliminates the necessity for placing hooks and springs to hold the various parts together. (3) Since the appliance is in one part, cleaning and home care are far more practical from the patient's point of view. Some operators have discouraged the use of the hollow bulb, feeling it was contraindicated because of the impossibility of making adjustments after placement.

This difficulty may be anticipated in the planning stage, and, if a proper thickness of material is used in the bulb, minor adjustments may easily be made.

In this type of prosthetic work the need for close cooperation between the surgeon and dental prosthetist cannot be overemphasized. Both should see the

Fig. 20.—Appliance in position in patient's mouth. Note the relationship to the natural teeth.

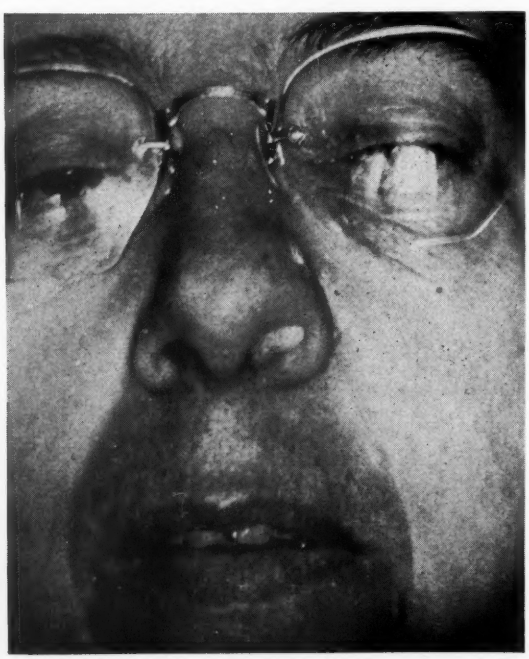

Fig. 21.—Normal facial contour re-established by insertion of the appliance.

patient prior to surgery and plans should be made at that time for the construction of appliances which will prevent the soft tissues of the cheek or lips from receding and becoming adherent through the formation of cicatricial tissue, thus causing unsightly defects. This cooperation proved such a boon during the war that it should by all means be continued in civil practice. By this means, many patients may have a happier existence.

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PARTIAL DENTURE DESIGN

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THE correlation of partial denture design with the actual movements of the mandible will aid the practitioner in successfully resolving partial denture cases.

The technique described here is based on the interpretation of centric position as the most retruded natural position in the glenoid fossa to which both condyles will return after completing masticatory or articulatory movements. This pattern is innate and constant. The muscles always attempt to elevate the condyles into this position unless they are impeded by a prematurity of tooth contact. When the prematurity creates a position of the mandible that cannot be retained, the mandible ricochets into a series of destructive movements culminating in a functional bite.[1]

In terms of partial denture design, this philosophy signifies that any clasp that has its rest on the distal part of a tooth, with its arms extending anteriorly, would be attempting to brace itself against a nonexistent force. Kennedy bars, continuous clasps, and indirect retainers placed in the anterior regions of the mouth, which are designed to prevent the appliance from moving forward, would fall in a similar category.

Of all the movements of the mandible, straight protrusive is the least important, since the condyle cannot brace itself against the walls of the glenoid fossa to exert maximum force.

The positions which cause the greatest amount of disturbance to an appliance are lateral protrusive and the working bite, as the muscles are always attempting to return the condyles to centric. Therefore, an appliance should be constructed to brace itself against these forces. Any abnormal settling of a denture anteriorly indicates that the patient's mandible is out of centric, and that protrusive pathologic ricochet movements are warping both the occlusion and the appliance.

In this connection, it may be reasoned that one of the principal reasons for the loosening of the female component of a precision attachment is that the tooth is not used to brace the attachment in order to help distribute the force directed diagonally toward the posterior.

The skeleton of a partial denture should be constructed in accordance with the following principles in order that the finished product may function in harmony with the innate mandibular movements.

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BASIC TENETS

1. The simpler the design, the more efficiently the partial denture will function. Unnecessary appendages lead to an accumulation of food debris and ultimately to oral breakdown.

2. The rests should be on the mesial aspect of the teeth, with the clasp arms extended posteriorly.

3. The clasps are intended for lateral bracing, not for resistance to tacky foods. They should be made to fit on the widest part of the tooth, and not into any undercut area. Pressure created when a clasp is in an undercut area results in too much damage to the tooth. These are the forces employed by the orthodontist to move teeth.

4. Retention should be obtained by (a) centric force, (b) close adaptation of the clasp to the tooth, and (c) the adhesiveness of the mucosal base.

5. In a maxillary bar design, the bar should be placed as far back as possible, but with adequate latitude to function not only for rigidity, but also as a brace. If the mucosal and palatal aspects of the impression are taken with a minimum of tissue displacement, there should be no objection to designing the bar over the hard areas. In the author's experience with full dentures (maxillary), no tissue pathosis, no "rock," no denture breakage has ever ensued when this principle was applied, even though no relief was provided for the hard area in the palate.

TECHNIQUE

The test of any denture is the manner in which it functions in the mouth. Any food debris left on a denture after the patient has consumed a meal indicates that there is a malfunction in that area. We cannot hope to achieve an accurate centric relation if there is movement in the base of the denture. The more stable the appliance, the better the centric relation. The following procedure incorporates these principles:

1. The impression may be taken in hydrocolloid, alginate, or by a sectional procedure, depending upon the individual requirements of the case.

2. The skeleton casting is designed as described in the foregoing paragraphs.

3. The casting is tested in the mouth. Complete accuracy in reproduction is not possible, regardless of the impression material employed. The skeleton casting will not fit the mouth in exactly the same manner as the impression because of discrepancies in the duplication and casting technique. The larger the partial denture, the greater the inaccuracy. For this reason the saddle area cannot be expected to function in the same manner as the clasps and rests. If the clasps or rests bind, or exert undue pressure on the teeth (which cannot be seen), the saddle area will not fit the mucosa despite the utilization of an impression technique which would record the tissue at rest.

4. To overcome these discrepancies:

(a.) Several thicknesses of tin foil are glued with rubber cement to the edentulous areas of the cast. A tray, made of an accelerated resin, is molded

by hand on the tin foil into the form of an undercut bite block. The cast need not be flasked, nor a counter die poured. The tray is attached to the skeleton casting by the accelerated resin. (See Figs. 1 and 2).

(b.) After the resin has cured for twenty minutes, the tin foil is removed from the cast, and the casting, with the trays attached, is placed in the mouth. It is then trimmed free of muscle attachments.

Fig. 1.—*a*, Initial cast made from a hydrocolloid impression. *b*, Partial denture skeleton casting with untrimmed accelerated resin trays attached.

Fig. 2.—Skeleton casting in place on the cast. Note the design of the clasp arms extended distally from the rests to resist the disturbing forces of mastication. The accelerated resin is attached to the skeleton casting over tin-foil spacers on the saddle areas.

(c.) After ascertaining that the rests fit as well as when the casting was originally tested in the mouth, an Ackerman paste impression is made in the saddle areas, with the rests perfectly in place.

(d.) When the impression paste has set, it is removed from the mouth, cleaned, and trimmed. Then it is replaced to test for stability. There should be

no "rock" or "give" of the skeleton casting and saddle impression, especially in a free-end saddle case.

(e.) An alginate or hydrocolloid impression is made over the skeleton casting with the saddle area impressions attached, while it is seated in the mouth. (See Fig. 3.)

A maxillary partial denture, with a palatal bar, must have a slightly different design to get a pressure-free impression of the palatal surface. When the skeleton casting is being prepared, the surface to be covered by the palatal bar must be relieved and waxed as if it were a saddle area (see [a.] above), bearing in mind that acrylic will eventually be attached to the structure in contact with the mucosa. When the accelerated resin tray is being attached, provision must be made for the palatal bar as well as the saddle areas. Then the procedure is similar to that followed in making a mandibular partial denture impression.

Fig. 3.—The completed impression. *a*, The Ackerman paste impression of the saddle areas is surrounded by *b*, an alginate impression made over it and the skeleton casting and the paste impression in the mouth.

5. The final step in the technique is the curing of the denture. Inasmuch as denture resins are not completely accurate in reproduction, steps must be taken to correct the discrepancies. The separating media used to cure a denture on its musocal aspect are: thin tin foil with soap or petroleum jelly added to insure its separation from the acrylic, wrinkle-proof cellophane, one of the Tec products, or DenSilk. Even when these are utilized, space develops between the plastic and the cast. One of the major reasons for bleaching of acrylics in processing is the water in the cast or plaster. This may be corrected by dehydrating the casts for seventy-two hours or more at a temperature of 90° F. Then the casts are immersed in an oil bath under a vacuum. After all the air has been eliminated, the

atmospheric pressure is allowed to enter and completely impregnate the casts by leaving them in the oil bath overnight. The oil-impregnated cast is protected from chipping during the process of registering the jaw relations. By the time the denture resin is ready for packing, the cast will be bone dry. The oil will prevent the resin from adhering to the cast in curing. No defects have been observed in the denture base as a result of this process, but accuracy of reproduction has been greatly improved.

CONCLUSION

Our conception of centric relation is that it must harmonize with the actual physiologic movements of the mandible. An interpretation of these movements indicates a simple method of constructing partial denture appliances so they will function efficiently and with a minimum of oral breakdown.

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DISTORTION OF GOLD PARTIAL DENTURE CASTINGS*

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GROSS warpage of gold alloy removable partial denture castings is an occurrance which has caused considerable concern to those persons interested in partial denture construction. The literature on cast gold removable dentures gives no indication of either the extent or frequency of which warpage exists.

It was the purpose of this study to determine the percentage of failure to be expected as a result of casting distortion; and also the magnitude and nature of warpage in these cast structures. To obtain this information, both a survey of student technique cases and precision measurements of laboratory test castings were planned.

In the construction of the casting there are several possible sources of warpage which may contribute to casting failure. Some distortion may originate with the simple mechanical bending due to accident, such as might occur through dropping the casting, careless removal from the casting or soldering investment, or from entangling a clasp or rest in a polishing wheel. The majority of ill-fitting castings, however, exhibit a certain common or characteristic type of deformation which is not typical of distortion caused by mechanical accident. Warped castings often show a tendency for the lingual bar to "open up," i.e., for the distal extremities of the casting to move bucally. In some castings, a tendency is also evident for the distal portion of the lingual bar to twist about its axis, such that the superior border of the bar tends to move lingually, and the inferior border moves bucally.

This repetition of similar types of deformation in many of the poor fitting structures causes one to consider seriously the possibility of whether or not actual warpage of the gold alloy is taking place. It is claimed by many that this distortion is the result of certain strains and stresses set up in the crystalline structure of the alloy at some stage in the construction sequence and released at another.

To determine the nature and extent of these changes, the design of the particular technique case in this study consisted of a mandibular Class I removable partial denture, replacing first and second molars on each side. This casting, shown in Fig. 1, is composed of a cast half-pear shaped lingual bar joined by minor connectors to occlusal rests on the distal of the second bicuspid, and to indirect retainers on the mesio-occlusal of the first bicuspids. The clasps consist of wrought buccal retentive arms and lingual reciprocal arms of the cast-bar type.

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**This report is a portion of a thesis submitted by E. J. Dinger in partial fulfillment of the requirements for the Master of Science degree in Dentistry. The study was started under the direction of Dr. N. O. Taylor, now with the S. S. White Dental Mfg. Co., Philadelphia, Pa.

SURVEY OF TECHNIQUE CASTINGS

The first step in this study was to make a survey of a group of castings made in a student technique course. Seventy-nine Junior dental students were asked to cooperate in making the study. Each student was asked to have the adaptation or fit of his casting examined immediately upon completion of each of the following steps in the technique:

1. Method of cooling after casting.
2. Preliminary polish and the cutting of the sprues.
3. At time of clasp assembly.
4. After soldering operation.
5. Following adaptation of retentive clasps.
6. Following annealing operation.
7. After hardening operation.
8. After final polish.

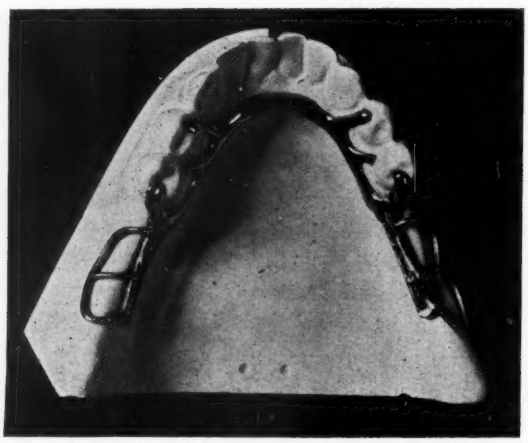

Fig. 1.

In checking the fit of these castings, no attempt was made to measure changes in microscopic detail. Attention was given only to changes gross enough to be discovered by careful visual examination. It is realized that many small changes may occur which will not significantly alter the fit of the casting. Such minor changes are of little practical importance since they are not likely to alter the usefulness of the prosthesis and are so small as to go unnoticed.

The castings were sprued through the bottom of the refractory cast by three ten-gauge sprues leading respectively to the center and each end of the major-connector from a wax reservoir at the base of the mold. One fourteen-gauge sprue led from the wax reservoir to the lug in each saddle area. The wax patterns were invested in Ransom and Randolph Grey investment and the wax eliminated at 1300°F. for one hour previous to casting. The metal used was a hard partial denture gold alloy—Ney-Oro G-3. The students were required to do all of the grinding and initial finishing before cutting the sprues in an attempt to decrease

the chances of mechanical distortion. After cutting the sprues, the castings were adjusted to the master casts. The right wrought retentive clasp had been incorporated in the wax pattern and so became an integral part of the structure at the time the casting was made. The left clasp was later positioned and soldered to place. The final adaptation of both wrought retentive clasps was then accomplished. At this point, the casting was annealed (softened) by heating it to a temperature of 1300°F. in an oven and then plunging it into room temperature water. The casting was then hardened by placing it in a salt bath at 350°C. for ten minutes, after which it was quenched and given its final polish.

Often there is some question as to whether or not any of the following three alterations in technique might have a significant effect upon the final fit of the case. (A) Should the casting be plunged into water as soon as the sprue begins to turn black or allow the casting to bench cool? (B) Should one plunge the casting immediately upon completion of the soldering operation or allow it to bench cool? (C) Should the casting be supported by investment during the softening part of the heat treatment, or should it be placed in the furnace unsupported? There was a full realization that by introducing these variations in technique, a possibility existed of confusing the issue, and of cutting down the size of the sampling to a point where little more than general indications might be drawn in the form of conclusions. It was decided, however, to divide the seventy-nine castings of the class into four major groups, each of which was further divided into two minor groups (A and B) in the following manner:

Group IA and IB (Castings 1 through 20).—
Plunge casting six minutes after casting.*
Support casting with investment for the annealing process.

Group IIA and IIB (Castings 21 through 40).—
Bench cool casting after casting.
Support casting with investment for the annealing process.

Group IIIA and IIIB (Castings 41 through 60).—
Plunge castings 6 minutes after casting.
Place casting in furnace unsupported for annealing process.

Group IVA and IVB (Casting 61 through 79).—
Bench cool casting after casting.
Place casting in furnace unsupported for annealing process.

Castings in Groups IA, IIA, IIIA, and IVA were quenched immediately upon completion of the soldering operation, while Groups IB, IIB, IIIB, and IVB were allowed to bench cool after soldering.

SURVEY FINDINGS

A brief summary of the findings of this survey of technique castings is shown in Tables I and II. Seventy-six of the seventy-nine castings completed fit the master casts well enough to stand a good chance of success in a practical situation,

*Six minutes is the time necessary to allow the sprue to reach a dull red to black color.

and three castings were discarded as poor fits. Of the seventy-six usable castings, forty were nearly perfect, while the other thirty-six all showed some minor discrepancies which, although possible indications of an error in technique, were probably not great enough to impair seriously the value of the casting.

Group I.—

Thirteen of the twenty castings included in this group showed some discrepancy in accurate fit at one or another point in the construction procedure. Six of these distorted structures showed definite improvement at some later time, prior to finishing. Three showed tendencies to fit poorly after step 3 (preliminary polish and sprue cutting). Two were definitely the result of overpolishing of the contact surfaces of the occlusal rests. Six castings showed discrepancy of fit after the soldering operation. Three of these were quenched immediately, and three were bench cooled after soldering. One casting ceased to fit well after the annealing process. Five others showed definite improvement in fit after this step. Three castings showed some distortion after the hardening operation. In summary of the results of this group, seven castings fit well, twelve showed minor discrepancy in fit but were acceptable, and one casting was a very poor fit.

TABLE I. GROUP DISTRIBUTION OF DISTORTION

CASTINGS	RATING W.R.T.FIT	GROUP DISTRIBUTION			
		I	II	III	IV
76	Usable Castings	19	20	19	18
40	Good Fit	7	14	8	11
36	Acceptable Fit	12	6	11	7
3	Poor Fit	1	0	1	1

TABLE II. DISTORTION DISCOVERY WITH RESPECT TO STAGE OF CONSTRUCTION

GROUP	CASTING	COOLING	PRELIMINARY POLISH AND SPRUE CUT	CLASP ASSEMBLY	SOLDERING	CLASP ADAPTED	ANNEALING	HARDENING	FINAL POLISH
I	—	—	3	—	6	—	1	3	—
II	—	—	—	—	3	—	2	1	—
III	—	—	5	—	3	—	3	—	1
IV	—	—	3	—	2	—	1	—	2

Group II.—

Six of the twenty castings in this group showed signs of imperfect fit at one step or another in the construction sequence, and one of these later showed improvement. Three cases showed inaccurate fit after the soldering operation, one of these having been quenched and the other two bench cooled after soldering. Two cases first showed signs of ill fit after the annealing process, and one case was apparently distorted during the hardening operation. Thus, in this second group, fourteen castings fit very well, six had slight discrepancies, but all were acceptable.

Group III.—

Twelve of the twenty castings in this group showed a tendency toward distortion at some step in the construction procedure, and two of these improved at some later step. Five of these showed discrepancies after the initial polish and sprue cutting; of these, four were definitely due to overpolishing of the rest surface. Three cases had one major occlusal rest out of contact after the soldering operation, two having been water quenched after soldering and one bench cooled. Three structures first showed signs of distortion after the annealing process. One showed an apparent increase in distortion after hardening, and one showed slight improvement. One casting was distorted beyond use in an accident during final polish. Thus, eight castings in this group fit perfectly, eleven were acceptable, although showing minor effects of distortion, and one casting was distorted beyond the point where it was of any practical value.

Group IV.—

Eight of the nineteen castings in this group had the accuracy of their fit reduced at some point in the process of construction, and three of these showed some improvement in a subsequent step. Three first showed signs of poor fit after the initial polish and sprue cutting. One other casting failed to fit because the wax pattern had apparently come loose and allowed secondary investment to creep under it. Two more casts showed a slight tendency to fit poorly after the soldering process. Both were bench cooled after soldering. Two casts showed definite improvement during the annealing process, and one seemed to improve during the hardening process. In summary, eleven castings of this last group were found to fit perfectly, seven had some slight discrepancy, but were acceptable, and one was a very poor fit.

In Table I it is shown that the seventy-six usable castings were evenly distributed among all four groups. This is significant since it might be interpreted to indicate that the three variations introduced into the technique had little influence upon the quality of the castings. The fact that a greater percentage of the good fitting castings were found in Groups II and IV, while the higher percentage of "acceptable" castings were found in Groups I and III, might seem to indicate that bench cooling after the casting procedure is more desirable than quenching or plunging into water.

A study of Table II shows that the occurrence of warpage during the various steps of construction is quite evenly distributed with respect to each of the four

groups in any one step. This might lead one to think that as far as distortion is concerned, apparently it made little difference whether the casting was initially quenched or bench cooled after soldering. Likewise, distortion was not related to the casting being invested or unsupported during the annealing operation. It should be remembered, however, that intercrystalline stresses may be set up in a casting during one operation, but not make themselves apparent until released by a later operation, to result in warpage. The operation in which the warpage becomes evident, therefore, may not be the entire source of the trouble.

LABORATORY STUDIES

With the findings of the casting technique survey available, the purpose of the laboratory study was to determine the magnitude of the distortion, and at what point in the operation the warpage was most likely to occur. This involved a further study of whether or not any relationship existed between the distortion of the structure and the technical procedures of casting, cooling, soldering, annealing, and hardening.

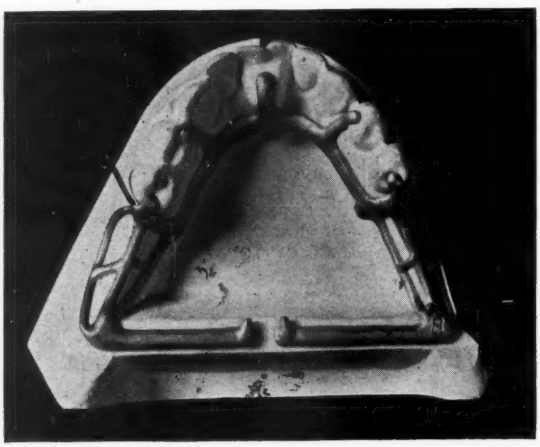

Fig. 2.

A casting design was chosen (Figs. 2 and 3) which incorporated most of the physical characteristics of the technique case described previously, and at the same time facilitated ease of effective measurement. In these laboratory studies more precise physical measurements were attempted, although the interest still was primarily in distortions which were gross enough to be detected through simple visual examination of the casting on the master cast.

The same basic design which had been used in the student technique survey, with the following slight alterations, was adopted for use in this study. A horizontal rest area was placed on the lingual surface of the central incisors (Fig. 2), and an 8-gauge half round bar was extended from the distal end of the denture base retention-lug, lingually on a horizontal plane to within 1 mm. of the midline of the tongue area. The purpose of this extension was to provide a long lever which would indicate in a magnified manner any tendency of the distal ends of the major

connector to twist about its axis. Three small cross lines were cut in the model, one on the rest area between the central incisors and one at the union of the lingual extension and the retention lugs on the crest of the ridges behind the position of the second molars. These horizontal reference points were indicated by the letters *A, B,* and *C; "A"* referring to the point between the central incisors, *"B"* to the point behind the left second molar, and *"C"* referring to the point behind the position of the right second molar.

The problem of accurately duplicating many casting and master casts on which to produce and check the experimental castings was solved in the following manner. A permanent rubberlike mold of the original master cast was made. This mold was prepared from a resin material sold under the trade name of V.B.M. and manufactured by the Vernon-Benshoff Company of Pittsburgh. All indications show

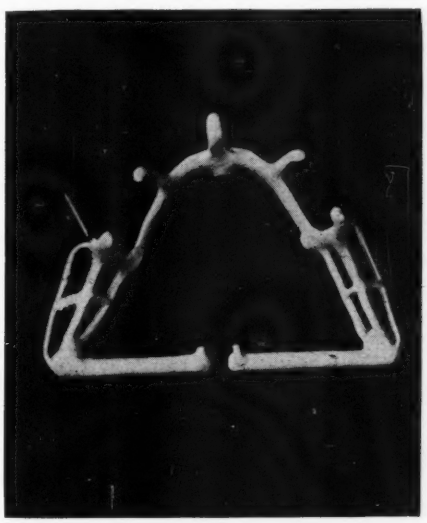

Fig. 3.

this material to be relatively stable dimensionally once it has been processed and the initial curing shrinkage has taken place. All master and casting models were poured in this mold. Recognizing the chance that some slight dimensional change may possibly take place in this material over a long period of time, both master and casting models for any one particular casting were always poured on the same day.

Horizontal measurements were first checked by use of a micrometer microscope to recheck the distances *BC, AB,* and *AC* after each successive step in the procedure. It was soon discovered, however, that no appreciable change could be found in any of the horizontal measurements even after visible vertical distortion had occurred. On the contrary, it was found that any visible distortion could be easily measured in a vertical direction by the simple means of a feeler gauge. Therefore, horizontal measurements were discontinued and all data were based upon vertical change, using feeler gauges graduated in 0.0015 inch, inserted between the cast structure and the model.

A total of eight castings was made in this study. The metal used was Ney ORO G-3 gold alloy, which was loaned by the J. M. Ney Company for this specific purpose. The first four castings were exposed to a series of nine consecutive treatments which did not follow the standard sequence of events as set up for the technique cases, but included several hardening and softening procedures specifically intended to warp the castings, if possible. The last four castings were put through the same steps in the same sequence as the standard technique castings. All castings were treated in pairs, i.e., numbers 1 and 2, 3 and 4, 5 and 6, 7 and 8 were studied simultaneously.

The first two castings were put through the following sequence of treatment:

1. Water quench six minutes after casting.
2. Sprues cut.
3. Hardened in a salt bath at 350°C. for twelve minutes—quenched.
4. Annealed—heated unsupported in an oven to 1300° F. for ten minutes and water quenched.
5. Hardened in an oven by dropping the temperature from 840°F. to 480°F. in fifteen minutes.
6. Annealed—as in step four.
7. Soldered right retentive clasp and then bench cooled.
8. Annealed—as in step four.
9. Hardened—as in step three.

The first tendency toward misfit of both of these castings was discovered after step 8, the annealing process which followed the soldering operation. The fit of both castings became generally worse after the final hardening procedure indicated in step nine. Table III outlines the position and magnitude of each observed discrepancy. The final extent of distortion in both these castings was great enough to make them unfit for practical service.

Castings 3 and 4 were subjected to the following sequence of treatment:

1. Bench cooled after casting.
2. Sprues cut.
3. Annealed—casting supported by investment in an oven at 1300°F. for ten minutes and then water quenched.
4. Hardened in a salt bath at 350°C. for twelve minutes—quenched.
5. Annealed—as in step two.
6. Hardened in an oven by dropping the temperature from 840°F. to 480°F. in fifteen minutes—quenched.
7. Annealed—as in step two.
8. Soldered right retentive clasp and then bench cooled.
9. Annealed—as in step two.
10. Hardened—as in step three.

Both casting 3 and casting 4 showed the first sign of vertical change after step 5, the second annealing process. Examination of Table III shows that in both castings

the first slight distortion was noted in the region of the denture resin retention lugs and the lingual extensions. It was not until after the hardening process of step 6 that any distortion was noticed in the region of a major occlusal rest, and then it occurred only in the left rest on casting 3. However, the distortion, shown by the retentive lugs and lingual extensions of both castings, increased gradually with each of the succeeding steps until after the tenth and final treatment enough warpage had occurred to make both cases unfit for practical service. Casting 4 first showed an ill fit of its major occlusal rests on each side immediately following the annealing process indicated in step 9.

TABLE III. VERTICAL DISTORTION IN MILLIMETERS

CASTING NUMBER	RIGHT SIDE				LEFT SIDE		
	STAGE OF CONSTRUCTION	OCCLUSAL REST	LINGUAL EXTENSION	DISTAL OF LUG	OCCLUSAL REST	LINGUAL EXTENSION	DISTAL OF LUG
1	8. A*	0.1016	—	0.2540	—	—	0.3048
	9. H†	0.4572	—	0.6350	0.1016	0.2032	0.4064
2	8. A	0.1016	0.2032	0.4572	0.1016	—	0.3048
	9. H	0.3048	—	0.4572	0.1016	0.2032	0.2032
3	5. A	—	0.4064	0.4064	—	0.4064	0.4064
	6. H	0.1016	0.6350	0.5588	0.1524	0.7620	0.5588
	7. A	—	0.5080	0.3556	—	0.5080	0.2032
	8. S‡	—	0.3556	—	—	0.4572	—
	9. A	0.2032	0.8636	0.4572	0.1524	1.0668	0.5080
	10. H	0.2032	0.9144	0.5080	0.1524	1.0668	0.5080
4	5. A	—	0.4572	0.2032	—	0.3556	0.2032
	6. H	—	0.4572	0.2286	—	0.3556	0.1524
	7. A	0.1270	0.9652	0.3556	—	0.5080	0.1524
	8. S	0.0508	0.8636	0.1524	—	0.4826	—
	9. A	0.2032	1.0219	0.5588	0.2032	0.7620	0.4572
	10. H	0.1524	1.0160	0.5080	0.2032	0.7620	0.3048
5	4. A	—	0.1270	0.1270	—	0.4064	—
	5. H	0.1016	0.3048	0.3048	—	0.5080	0.2032
6	3. S	—	—	—	—	0.1270	0.1270
	4. A	—	0.4064	0.2032	0.0508	0.3556	0.1016
	5. H	—	0.5080	0.2032	0.0508	0.4572	0.1524
7	4. A	—	0.2540	—	—	0.2540	—
	5. H	—	0.3556	0.0508	0.0508	0.2032	0.0508
8	3. S	—	—	—	—	0.1524	0.1524
	4. A	—	—	—	—	0.2540	—
	5. H	—	—	—	—	0.3556	0.3048

*A—Annealing.
†H—Hardening.
‡S—Soldering.

The final four castings, 5, 6, 7, and 8, were treated identically, with the exception that 5 and 6 were plunged into water six minutes after casting, and 7 and 8

were bench cooled. The following sequence of treatment was the same as that used for the Junior technique castings.

1. Castings 5 and 6 bench cooled, with 7 and 8 quenched six minutes after casting.
2. Sprues cut.
3. Right retentive clasp soldered and casting quenched immediately.
4. Castings supported by investment and annealed by carrying to a temperature of 1300°F. for ten minutes and plunged into water.
5. Hardened in a salt bath at 350°C. for 12 minutes and then quenched.

Casting 5 showed some slight changes in the position of the retention lugs and lingual extensions after step four—the annealing process. The condition became generally worse after the hardening treatment. At this time the right major occlusal rest was found to be 0.1016 mm. off the tooth. Casting 6 showed slight lifting of the left major occlusal rest after the annealing process, and this situation remained unchanged through the hardening operation. The retentive lugs and lingual extensions also showed discrepancies of fit after annealing, and these became worse after heat treatment. Casting 7 showed very slight changes in the distal region of the retention lug and the lingual extensions following the annealing process. These remained much the same through the hardening process, but the left major occlusal rest was then found to be very slightly off the tooth. Casting 8 showed no discrepancies in the fit of any major occlusal rests at any time. Only slight errors in fit of the left retentive lug and lingual extension were observed following the annealing and hardening operations. All of the last four castings were finished in a condition easily acceptable for practical service.

Although measurements were made of possible changes of the indirect retainer of all castings, no measurable distortion occurred on either the right or left side of any of the eight castings. For that reason, no values are listed in the columns of Table III, although measurements were made on each casting.

SUMMARY

In the technique survey it is significant that three of the seventy-nine castings (3.8 per cent) were unacceptable. Of these, one was the direct result of the displacement of the wax pattern by secondary investment; one failure was due to accidental mechanical distortion during the final polish; the third failure was due to the casting being warped during the soldering operation. For the entire technique survey, thirty-six castings (45.5 per cent) showed some visible evidence of warpage, but not sufficient to prohibit their use. The majority of unexplained discrepancies occurred either after the soldering or the annealing operation. Eleven of the seventy-nine castings failed to fit properly after the initial polish and sprue cutting. Of these eleven, six misfits were the result of an over-polishing of the rest surfaces, and one was the result of the displacement of the wax pattern.

The laboratory studies show that eight castings developed slight discrepancies immediately following the soldering operation. These discrepancies increased with the successive stages of softening and hardening operations.

Both the technique and laboratory castings showed similar changes, with the only significant changes being in the severity of distortion. In nearly all castings the lingual bar tended to spread at its distal ends in such a manner as to force the section of the bar below the major abutment teeth into closer contact with the cast, sometimes to the point of serious impingement. At the same time a relief space tended to develop under the center section of the bar, lingual to the incisor teeth. The major occlusal rests showed a tendency to raise off the tooth surface, frequently more on the buccal surface, due to a twisting action of the major connector. This action tended to force the lingual portion of the resin retention lug into closer contact with the edentulous ridge, and the buccal portion of the lug farther from the ridge. Some castings which showed less of the twisting tendency and more of a straight spreading of the distal ends resulted in the major occlusal rests contacting only on the lingual slope of the buccal cusps with a resulting space under the lingual side of the rest.

When surveying all of the results for both the technique and laboratory studies, one factor seems to stand out from the others. The more heat treatment the castings receive, the greater are the chances of producing distortion. By heat treatment is meant any operation which consists of heating the casting to a high temperature and then cooling it. This included the casting process, together with the method of cooling, and the soldering, annealing, and hardening operations.

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STUDIES ON THE EFFECTS OF ABRASIVES ON ACRYLIC RESINS

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SINCE the first modern dentures were made, dentists and patients have been confronted with the problem of keeping dentures properly cleaned. Although many patients disregard care of the denture, others are aware of the importance of thorough cleansing. It is generally recognized that dirty dentures impair maintenance of good mouth hygiene, and food debris and bacteria growing in close contact with the oral tissues may result in inflammatory changes sometimes confused with reactions to denture materials or irritations due to ill-fitting dentures.[1] They serve as a constant source of irritation, and may often be a contributing factor in certain oral diseases. Neglected dentures can even produce tissue changes which necessitate premature construction of a new denture. Cleanliness must also be emphasized from the standpoint of maintaining esthetics and minimizing mouth odors.

Proper care of the finished denture by the patient has often been stressed,[2-8] and many types of materials and techniques advocated.[2, 3, 4, 6, 7, 8, 9, 10] There is no doubt that a wide variety of cleansing materials is being employed at the present time with little or no evidence to indicate their relative ability to clean safely the artificial denture. In order to determine what materials are most commonly used, a survey was recently made at Indiana University School of Dentistry. Three hundred seventy patients who came to the prosthetic clinic were questioned in regard to the cleanser employed, method of application, and frequency of use. In Fig. 1 are summarized the data concerning the types of cleansers used by this group.

It can be seen that while 24.3 per cent of the patients questioned did use some type of commercial cleanser manufactured specifically for cleaning artificial dentures, the greatest number, 38.3 per cent, employed a tooth paste or tooth powder. A wide variety of other materials was also reported, such as soap, salt, and soda. It is interesting to note that approximately 8 per cent made routine or frequent use of commercial household cleansers such as Old Dutch Cleanser and Bon Ami. A few even resorted to conventional bleaching agents such as Clorox.

Thus it can be seen from this survey of a typical cross section that a wide variety of materials is being used by denture patients. Unfortunately, the dentist does not have any criteria for intelligently evaluating these products, and is at a loss to know what materials to recommend. Because of their severe abrasive action,

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it is quite possible that some of these agents might have a deleterious effect on the denture base. Although they had no research data to confirm their beliefs, several writers have warned of this danger.[2, 6] Probably a slight abrasive action is desirable in order to remove stain, debris, and mucus, but the abrasiveness must not be of such magnitude that any gross scratching or removal of the denture base material occurs. A roughened surface produced by an extremely abrasive agent will pick up and retain stain and debris more rapidly. Scratches on the tissue-bearing surface will not only make it more difficult to maintain cleanliness, but also might become a source of tissue irritation. It is even possible that in severe cases the actual adaptation of the denture may be impaired. Since little scientific information is available concerning the possibility of deleterious effects being produced by some of the commonly used denture cleanser materials, it was believed that such an investigation would be most valuable. Therefore, the purpose of this study was to investigate the effects of denture cleansers on acrylic resins.

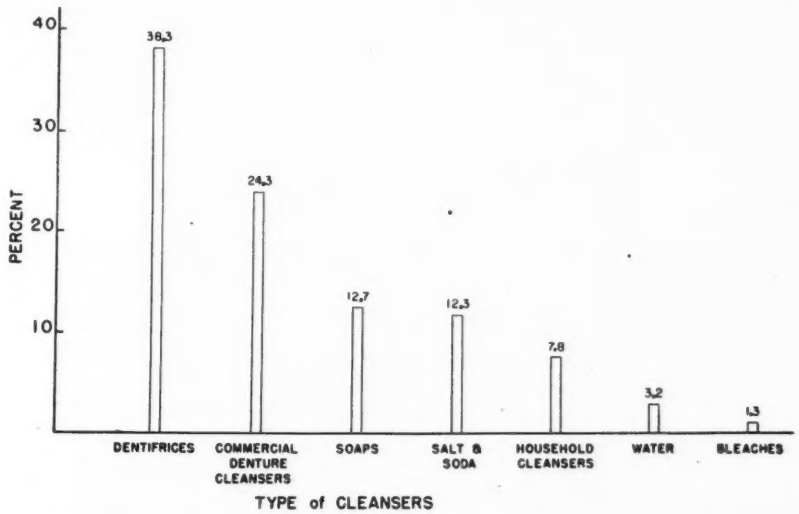

Fig. 1.—Per cent of patients using various types of cleansers.

Agents tested included household cleansers, bleaching agents, the commonly used proprietary materials, and several popular tooth powders and pastes. All products were purchased on the open market. Although actual names of the commercial cleansers are used in this paper, the dentifrices have been referred to by letters. These tooth powders and pastes are representative of many, and it is the purpose of this paper only to determine the effect of this general class of materials, not any particular brand.

PROCEDURE

Weight loss, luster changes, measurement of surface loss, and microscopic examinations of the surface were the methods employed in this study. A detailed description of each type of test will be discussed in the following section. The acrylic

specimens used in all these experiments were regular octagons prepared from a piece of resin approximately 5 mm. per side and 5 mm. thick. A typical specimen can be seen in Fig. 2. This particular design was employed in order that the specimen would fit on the special metal plate used with the luster apparatus. Hydrocolloid impressions were taken of this plate, wax patterns made, and then reproduced in acrylic by conventional dental procedures. Although there is some difference in the physical properties of various popular resins, only one accepted material was used. This particular acrylic is representative of the popular brands, and changes induced on this resin by various cleansers would undoubtedly be typical of present acrylic denture base materials. An accepted curing procedure was employed by placing the flask in a water bath at 160°F., holding for two hours, and then boiling for an additional hour. The specimens were allowed to remain in the flask overnight before removal.

The surfaces were rough polished by use of progressively finer emery papers on a motor-driven grinding wheel. The final wet polish was done by means of a felt wheel with Buehlers' Alpha polishing alumina. The wet polishing time was kept at a minimum in order to prevent any rounding of the specimen edges. All specimens were examined microscopically to assure the absence of scratches.

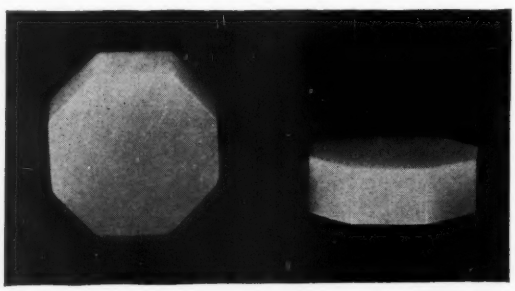

Fig. 2.—Typical acrylic specimen used in this study.

Weight Loss.—

For accurate determination of the amount of resin being removed during brushing, it was necessary to bring each specimen to constant weight. The method employed was the same as that outlined in A.D.A. Specification No. 12 (F-4). The samples were dried in an oven at 75± 2°C., cooled in a desiccator for one hour, and weighed. Weighing was done by means of an analytical balance. Specimens were considered at constant weight when the weight loss was no more than .0002 Gm. after any twenty-four-hour period. The same procedure was employed for re-establishing the constant weight after the specimen had been brushed or immersed in the denture cleanser.

The brushing of all specimens was done by a motor-driven brushing machine (Fig. 3) secured through the courtesy of the Pepsodent Division of Lever Brothers Company. Machine brushing eliminated many of the variables, such as pressure, speed, etc., which are associated with hand brushing. This particular machine is equipped with six brush holders and pans so that six specimens can be brushed simultaneously.

The acrylic specimens were mounted with compound on a metal plate of the same size as the specimen. (This plate fits into the micrometer stage of the luster apparatus which will be described later.) The mounted specimen was then secured in a recessed brass plate that fitted the dentifrice pans. Extreme care was used to adjust the position of the specimens so that the top would protrude 1 mm. above the brass plate and would be parallel to its top surface. This plate, with specimen properly placed, was then embedded with paraffin in the brushing pan. The pan and mounted specimen can be seen in Fig. 4.

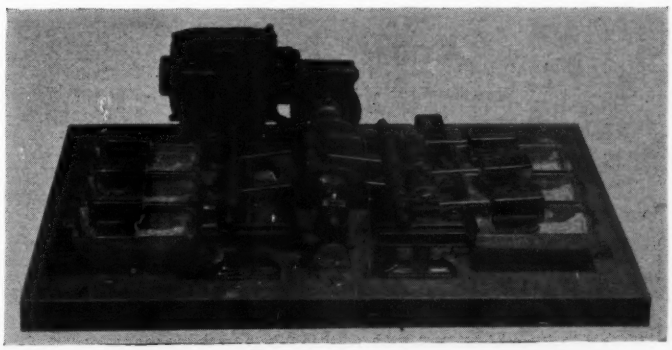

Fig. 3.—Mechanical brushing machine.

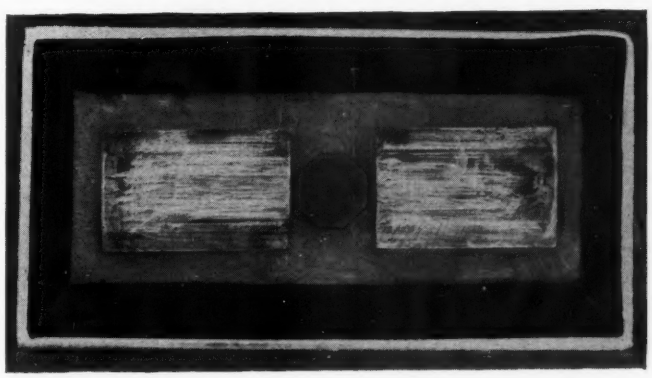

Fig. 4.—Pan with mounted specimen.

In order to secure maximum effect of the cleansers, nylon brushes were employed throughout.* Before the start of each test, the brushes were aligned so that the entire surface was being evenly brushed. The weight of the brush holder was 240 Gm.

The brushing period decided upon was 20,000 strokes. This arbitrary figure was based upon both actual observations of patients brushing their dentures and data secured in the survey previously mentioned. In Fig. 5 it can be seen that over one-half of the patients questioned brushed their dentures twice a day. If a specific area on a denture received fifteen strokes at each brushing and the dentures

*Pepsodent 50-tuft "hard" brushes, .013 inch bristle diameter, were used.

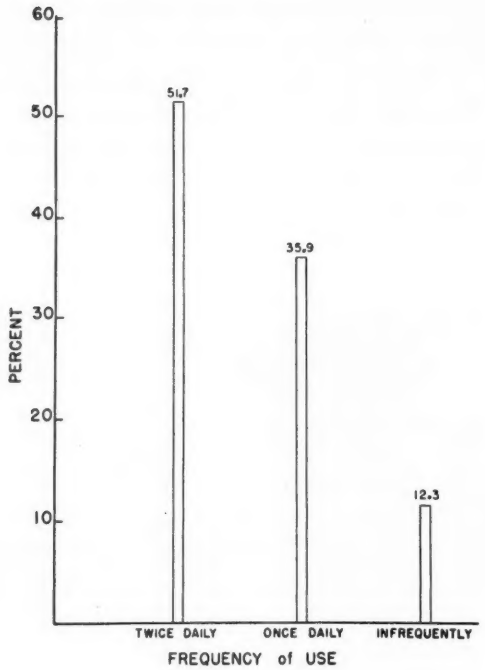

Fig. 5.—Frequency with which patients clean dentures.

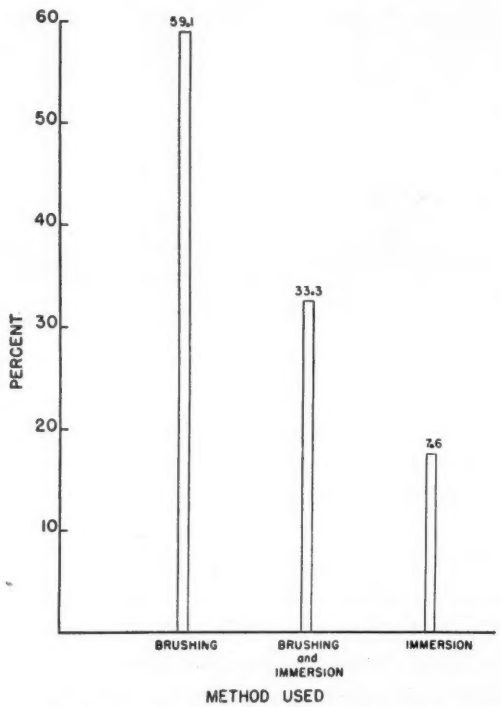

Fig. 6.—Per cent of patients employing various methods for cleaning dentures.

were brushed twice a day, then 20,000 strokes would be equivalent to approximately two years of cleansing. It is recognized that this number of strokes is probably greater than that used by some patients. For example, 12.3 per cent of the patients questioned reported only infrequent use of a cleanser. However, since a majority of the patients do brush their dentures twice a day, a brushing period of 20,000 strokes, or approximately two years of normal home care, was selected as it corresponds closely to average use and would emphasize any possible deleterious effect induced by a particular cleanser.

Many commercial denture cleansers are sold as immersion type of cleansers, and patients are instructed that immersion in the solution for a specified period of time will produce adequate cleansing. The cleansing power of these immersion materials, particularly on an old and dirty denture, is subject to question, and observations indicate that even when these materials are used the patient resorts to routine or frequent brushing with the cleanser. For example, in Fig. 6 are summarized data concerning the method employed by patients in cleaning artificial dentures. Of the 370 questioned, 59.1 per cent employed brushing only, while 33.3 per cent used a combination of brushing and immersion. Only 7.6 per cent of this group relied on simple immersion for the denture cleansing. It is apparent from these data that regardless of the recommendation of the manufacturer, immersion cleansers will also be employed as brushing abrasives by the patient. Thus in this study all immersion cleansers were tested not only for any effect by simple immersion of the acrylic specimens in a solution of the cleanser, but also by brushing for 20,000 strokes with the same cleanser.

It is recognized that the actual concentration of cleanser employed varies widely with different individuals. Some use the dry powder, while others employ a dilute solution. Observation, however, indicates that the majority of patients use a thick slurry. Naturally the actual amount of powder or paste necessary to obtain a thick slurry will vary for each cleanser. In this investigation, a standard of 10 Gm. of the cleanser was always used and enough tap water then added to make a thick slurry. As near as humanly possible, all slurries were made to the same consistency. The actual amount of water used for the different cleansers varied from 5 to 25 cubic centimeters.

When immersion cleansers were employed, various dilutions were tested. The manufacturers' directions were closely followed in the first tests but subsequent studies were made using a markedly higher concentration. The immersion times were varied from twenty-four hours to seventy-two hours. Bleaches were used both at the concentration recommended for bleaching of clothes and at dilutions of 50 per cent. Although this latter concentration is higher than commonly used, some patients will undoubtedly use a bleaching agent at approximately full strength.

Luster Changes.—

Maintenance of a high polish on the surface of the artificial denture is essential if the denture is to be easily cleaned and retention of stain and debris minimized. In order to detect minute changes in the luster or polish on the acrylic resin, a specially designed reflectometer was employed. These measurements thus served as another method of evaluating the relative abrasiveness of the various materials.

This particular apparatus can be seen in Fig. 7. Constant voltage for the light source was obtained by means of a 57 plate, 6 volt storage battery and controlled by a rheostat (*a*). A beam of light, 1 mm. in diameter, enclosed in an aluminum housing (*b*) strikes the specimen and is reflected into the photoelectric cell (*c*). This in turn activates a galvanometer (*d*). The smoother the tooth surface, the greater the reflected light, the less is the diffuse light and, consequently, the higher is the galvanometer reading.

The movable stage upon which the specimen is secured is calibrated so that the specimen can be placed in exactly the same position for each reading. In this photograph is shown the black Carrara glass standard which is used for adjusting the light beams to the same intensity before each measurement.

Luster readings were taken on the polished acrylic specimens both before and after brushing with each cleanser. Experimental error for this test is approximately two luster divisions.

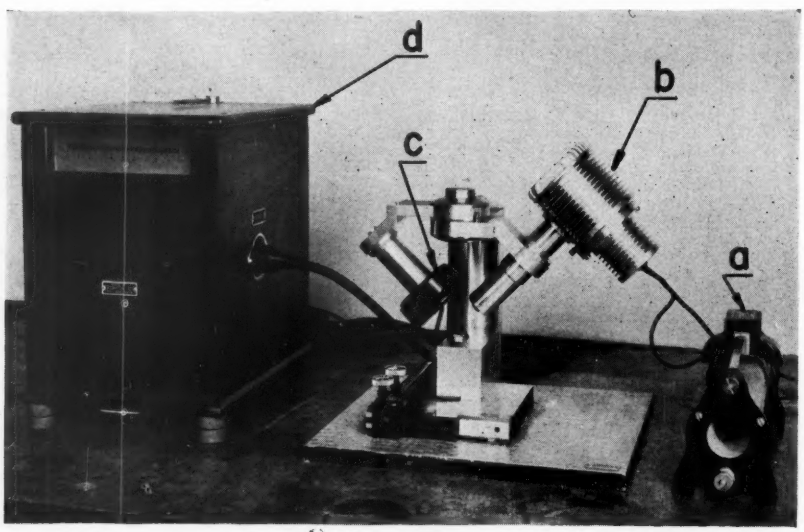

Fig. 7.—Reflectometer used for measuring luster changes. (Courtesy of the Pepsodent Division, Lever Brothers Co.)

Surface Loss Measurements and Microscopic Studies.—

The third method for detecting surface effect of the various cleansers was the measurement, in microns, of resin removed during brushing. Although weight loss determinations indicate the relative abrasiveness of the various cleansers, it is difficult to interpret these changes in terms of the actual reduction in width of the specimen. Data obtained showing the loss of resin in fractions of a millimeter would be valuable in attempting to correlate the clinical significance of these laboratory tests.

The measurement of surface loss was based upon a technique of focusing on the tooth surface by means of a Bausch and Lomb metallographic microscope, read-

ing the scale on the fine adjustment knob, treating the surface with the cleaning agent, refocusing, and then computing the surface loss in microns. This technique is a modification of one used by Manly[11] and identical to that employed by Bailey and Phillips.[12]

The acrylic specimen was mounted with compound on a specially prepared plastic disc which fitted into the stage aperture of the microscope. The disc and stage were marked so that the specimen could be removed and replaced in exactly the same position. Very pertinent to the success of this study was the necessity of being able to place the specimen in exactly the same position each time; thus any change in focus and the resulting reading of the vernier scale could be attributed solely to the effect of the abrasive and not to any change in the specimen position. Repeated tests by removing and replacing the plastic disc, with the specimen attached, indicated the maximum error to be one division on the fine adjustment scale, which is equivalent to 2.5 microns.

After the surface of the test specimen had been brought into focus a series of readings were taken across the entire surface. Stage readings of the microscope at each point were recorded so that after brushing the measurement of surface loss could be taken on the same areas. The specimen was then removed, treated with the particular cleanser, and replaced on the stage aperture. The surface was again brought into focus and the amount of acrylic removed computed. Measurements were taken across the entire area, and the maximum loss determined.

The surface of each specimen was studied microscopically before and after each test, and representative photographs were taken.

RESULTS

Weight Loss.—

In Table I (column 3) is summarized the average weight loss on stationary specimens after being brushed for 20,000 strokes with the different cleansers. Each of these figures represents the average of at least two individual specimens.

In order to determine what effect the brush itself might have, a series of tests were made in which the specimen was brushed with water as the brushing media. As shown at the bottom of column 3, the weight loss after 20,000 strokes was .0002 Gm. As the experimental error in this test is approximately .0002 Gm., then it can be seen that the nylon brush itself has little or no effect on the resin. Thus any marked subsequent weight loss with the various cleansers must be attributed to the abrasive itself and not the brush.

It is evident from the data in this table that a wide variation exists in the abrasiveness of the different commonly used cleansers. Only one of the proprietary materials made specifically for denture cleansing (Wernet's Dentu-Creme) produced any appreciable weight loss. All of these cleansers were less abrasive than the two dentifrice powders which were tested. The tooth pastes, of course, caused only moderate weight loss.

The most significant finding in this series of tests was the severe weight loss induced by the two household cleansers. Old Dutch Cleanser produced an average

loss of .0439 Gm., while the loss with Bon Ami was .0393 Gm. These weight changes are more than double that of the next most abrasive material tested (tooth powder A). Undoubtedly, this degree of abrasion is great enough to be injurious to the denture base, and subsequent tests will corroborate these data.

TABLE I.

MATERIAL	AVERAGE WEIGHT LOSS IN GRAMS	
	ROTATED	STATIONARY
Household Cleansers		
Old Dutch	.0438	.0439
Bon Ami	.0387	.0393
Dentrifices		
A (powder)	.0174	.0174
B (powder)	.0124	.0169
C (paste)	.0050	.0063
D (paste)	.0031	.0047
E (paste)	.0018	.0018
Commercial Cleansers		
Wernet's Dentu-Creme	.0127	.0133
Ora	.0035	.0040
Polident	.0009	.0009
D.O.C.	.0008	.0006
Kleenite	.0006	.0006
Plato	.0004	.0006
Miscellaneous		
Soda	.0011	.0015
Ivory Soap	.0004	.0006
Salt	.0003	.0003
Water	.0002	.0002

The miscellaneous agents tested such as salt, soda, soap, and water had little or no effect on the resin.

Microscopic as well as gross examinations of the specimens reveal a severe grooving of the resin surface when the more abrasive cleansers were employed. Figs. 8 through 11 show some of the roughened surfaces following brushing with the indicated cleansers. These specimens have been coated with graphite in order to accentuate the deep scratches. Such a technique was originally reported by Pickrell.[13] In order to secure a somewhat different perspective, these same specimens were carefully sectioned and photographs made with the resin surface held at right angles to the camera. Representative silhouette photographs taken in this manner can be seen in Figs. 12 through 14. The depth of many of these grooves is at least one millimeter.

This microscopic examination of these brushed surfaces indicates that a severe grooving action does take place with many of these cleansers. However, an immediate question that arises is why such conditions are seldom, if ever, observed clinically. Certainly the deep scratches such as produced by Bon Ami in Fig. 12 are not often manifested in even an old denture which has been brushed for many

years with a highly abrasive material. The explanation of this discrepancy must lie in the fact that all of these experimental specimens remained stationary throughout the brushing period. Thus the bristles of the toothbrush followed exactly the same path on each stroke. This constant wear in the same area produced a scratch. As the depth of this scratch increased, the surface exposed to the abrasive particles became greater, the abrasion accelerated, and grooves resulted. It was recognized that although the use of stationary specimens permitted an accurate comparison of the relative abrasiveness of the various cleansers, the actual denture base is not brushed in this manner. During the cleaning the denture is constantly moved

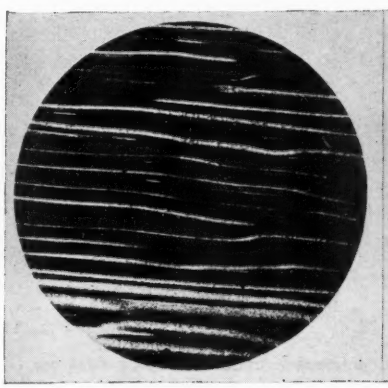

Fig. 8.—Surface produced by Bon Ami (×10).

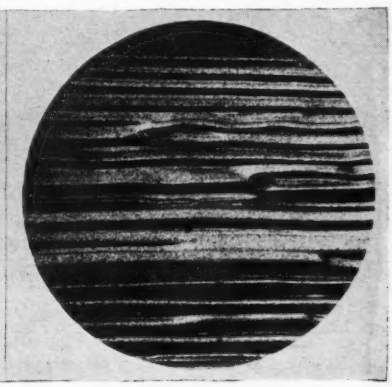

Fig. 9.—Tooth powder A.

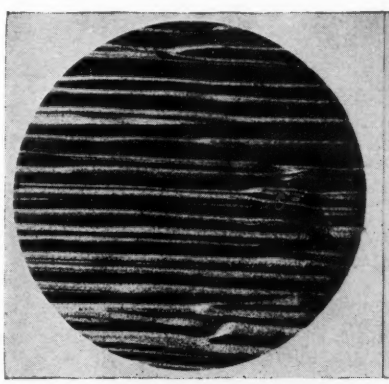

Fig. 10.—Wernet's Dentu-Creme.

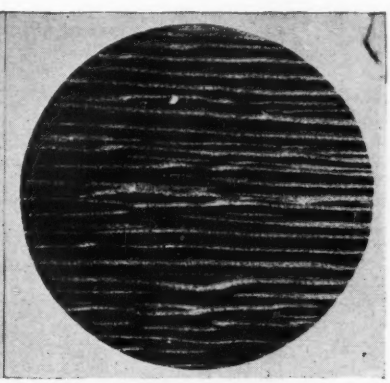

Fig. 11.—Tooth paste C.

and the individual bristles never follow the same identical path. The probable resulting effect would be a great number of small scratches with little chance for the formation of deep grooves. It is quite possible that in such a case the weight loss might be less than that when the specimen remains stationary. Thus, in view of the fact that from the clinical standpoint the previous data obtained on stationary specimens could be misleading, it was decided to develop a technique which would be more comparable to actual use of the cleanser by the patient.

A special dentifrice pan was constructed and can be seen in Fig. 15. By pushing the metal rod (*A*) a worm gear permits the turntable (*B*) to revolve. The acrylic specimen was securely attached to this turntable so that it could be rotated throughout the brushing period. The specimen was revolved approximately three degrees every fifteen seconds during brushing. It was felt that results on these revolving specimens would produce data which would be more closely comparable to what might be expected from clinical use of a denture cleanser.

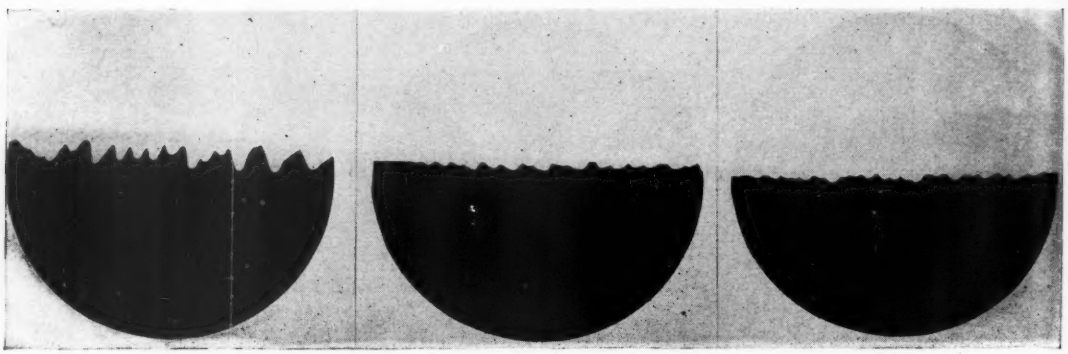

Fig. 12. Fig. 13. Fig. 14.

Fig. 12.—Silhouette photograph of surface brushed with Bon Ami.

Fig. 13.—Tooth powder A.

Fig. 14.—Wernet's Dentu-Creme.

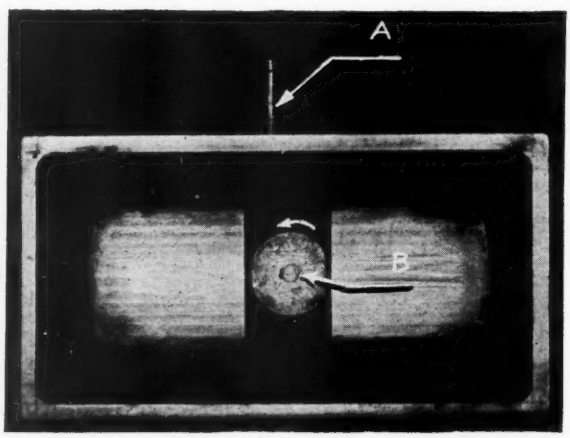

Fig. 15.—Special brushing pan for rotating the specimen.

The data obtained on these rotated specimens can be seen in column 2 of Table I. In general, the weight loss is approximately the same, or only very slightly less, than when stationary specimens were involved. For example the average weight change on a stationary specimen brushed with Old Dutch Cleanser was .0439 Gm. and when rotated the change was .0438 Gm.

The microscopic examination of these rotated specimen surfaces reveals no grooving action as was seen on the stationary samples, but rather a great number of small scratches running in many directions. Typical samples can be seen in Figs. 16 and 17. The brushing pattern induced by the constant change in specimen position is clearly evident. For comparison, in Fig. 18 is shown the surface

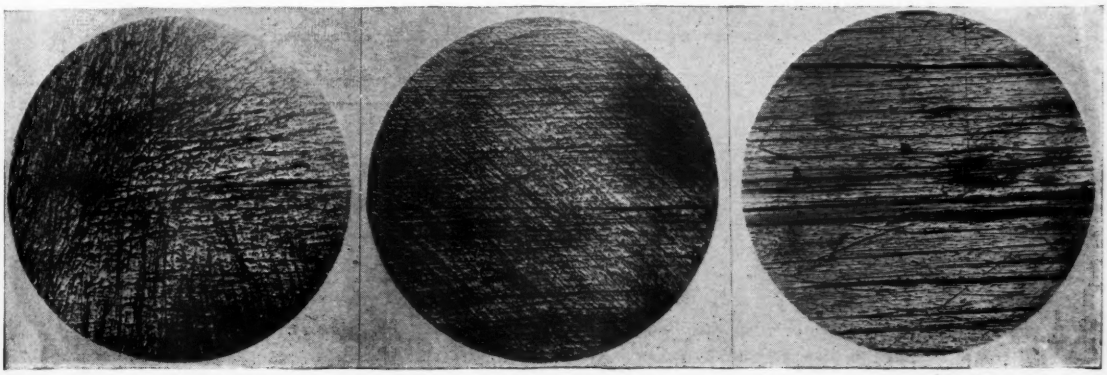

Fig. 16. Fig. 17. Fig. 18.

Fig. 16.—Surface of rotated specimen brushed with Old Dutch Cleanser (×60).
Fig. 17.—Rotated specimen brushed with tooth powder A.
Fig. 18.—Stationary specimen brushed with Polident. Note difference in abrasive pattern.

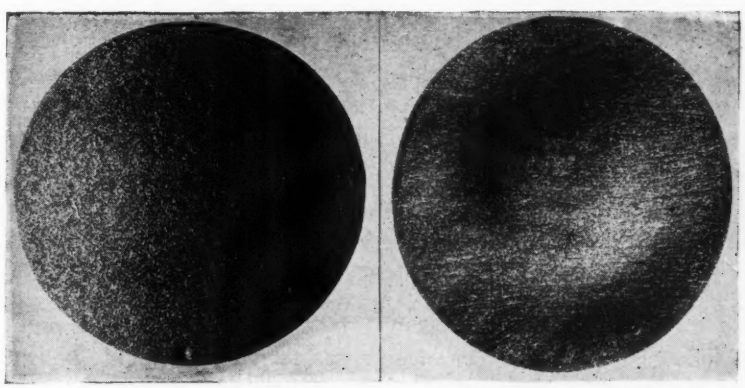

Fig. 19. Fig. 20.

Fig. 19.—Low magnification (×7) of rotated specimen brushed with Polident.
Fig. 20.—Surface brushed with Old Dutch Cleanser.

of a stationary specimen brushed with the very slightly abrasive Polident. The magnification is the same as that in Figs. 16 and 17. All the scratches on the specimen run in one direction. Gross examination of these rotated specimens, magnification only 7 times, revealed a general dulling of the entire surface. Two representative photographs are seen in Figs. 19 and 20. The appearance of these surfaces, brushed in this manner, closely corresponds to the clinical appearance of old dentures on which an abrasive cleanser has been employed. The surfaces are dull, but no definite scratching is apparent at this magnification.

From these tests it should be emphasized that although there are no deep grooves produced when the specimen is constantly moved during brushing, the weight loss is generally just as great. Therefore, even though clinically no particularly deep scratches might be evident, the actual loss of resin and the resulting change in the fit of the denture could be quite great.

TABLE II.

MATERIAL	AVERAGE WEIGHT CHANGE IN GRAMS	
	24 HOURS*	72 HOURS†
Polident	−.0001	+.0001
D.O.C.	+.0001	no change
Kleenite	no change	no change
Ora	no change	+.0001
Plato	no change	no change
Clorox	no change	+.0001
Purex	no change	+.0001

*Concentration according to manufacturers' directions.
†Saturated solution.

When specimens were immersed in solutions of several of these cleansers, no weight change above the experimental error occurred. Only the cleansers which were recommended specifically for immersion were used. In Table II can be seen the changes with these materials, both after immersion for twenty-four hours in the recommended concentration and after seventy-two hours continuous immersion in a saturated solution. As can be seen, no weight loss occurred and likewise no effect could be detected with the use of two household bleaches, Clorox and Purex. Specimens were also checked for color change, and none was observed. These data confirm the work of Docking,[14] who found no deleterious effect upon testing certain Australian immersion-type cleansers.

Luster Change.—

In Table III can be seen the loss in luster units on both rotated and stationary specimens following brushing. The luster was read on the highly polished surface before the start of each test and again immediately following brushing. These figures represent the average of at least two individual specimens. The data substantiate the previous findings in regard to the effect of the more abrasive cleansers on acrylic resins. In fact, when the stationary samples were employed, the luster changes on these cleansers reach the maximum change it is possible to obtain on this type of specimen. When the specimen is rotated, since the scratches are greater in number and less in depth, the luster change is correspondingly less. For example, Bon Ami produces a luster loss of 46 units when stationary, but only 26 units when the specimen was rotated. With most of the proprietary denture cleansers and the miscellaneous items such as salt and soda, the luster reducing tendency was minimized. Polident showed a luster loss of only 2 units after brushing for 20,000 strokes.

TABLE III.

MATERIAL	AVERAGE LOSS IN LUSTER UNITS	
	ROTATED	STATIONARY
Household Cleansers		
Old Dutch	30	45
Bon Ami	26	44
Dentrifices		
A (powder)	23	47
B (powder)	22	42
D (paste)	15	42
C (paste)	14	42
E (paste)	8	22
Commercial Cleansers		
Ora	20	39
Wernet's Dentu-Creme	19	45
Plato	7	17
Kleenite	3	7
D.O.C.	2	6
Polident	2	4
Miscellaneous		
Soda	12	25
Ivory Soap	7	12
Salt	2	3
Water	2	2

The luster changes on the rotated specimens followed the same general trend as the weight loss tests. Usually the greater the weight loss the greater also was the luster change. For example, Old Dutch Cleanser not only produced the most weight loss but also the greatest reduction in surface luster. There were some exceptions, however, such as Ora and Wernet's Dentu-Creme. Ora had considerably less weight loss than Wernet's, yet showed a very slightly higher luster loss.

The luster changes on the stationary specimens are not so closely correlated with the weight losses. The household cleansers, most of the dentifrices, and two of the commercial denture cleansers all produced maximum luster changes. In many of these cases the weight losses with these cleansers varied considerably. For example, Bon Ami which showed a weight loss of .0393 Gm. produced a luster change of 44 units, while tooth paste D with a weight loss of only .0047 Gm. caused a surface luster loss of 42 units. It is apparent from such data that once the dentifrice produces a grooved surface a maximum luster reduction is rapidly reached, and any further increase in the depth of the grooves does not appreciably lower the luster. Thus the rotated specimens serve as a better method for detecting changes in the surface luster as induced by the different denture cleansers.

Although it is possible that a high luster on a denture base is not necessarily desirable from an esthetic standpoint, a polished surface is important in keeping the denture as clean as possible. Recent research has shown that the bacteria collect and are retained more readily on a dull abraded tooth surface than on a highly pol-

ished one.[15] It could be anticipated that the same would be true on a denture base; thus a severely abraded resin would be harder to clean and more difficult to maintain free from stain and debris. Therefore, these data present added information pointing to the possible deleterious effects of the more abrasive cleansers which are employed.

Surface Loss.—

As has been shown in this paper, some of the materials tested produced drastic changes in the acrylic surfaces. These effects have been discussed in the sections on weight loss and luster changes. It was evident in those tests that much resin was being removed by the cleanser even when a rotated specimen was employed. However, the actual amount in terms of millimeters of resin surface was not known. It would be difficult to compute from the weight loss on these specimens the actual change in cross sectional area. Such data would be valuable in determining the clinical change which might occur with use of the more abrasive cleansers. Thus the following series of tests were made.

As previously described, these measurements were made by means of a Bausch and Lomb metallographic microscope. Only the rotated specimens were used since they corresponded to the clinical use of the cleansers. Although visually the surface of these specimens did not appear to be altered appreciably, the weight loss tests indicated that considerable surface loss had occurred. As shown in Table IV, there was a wide variation in the amount of resin removed by brushing with the different cleansers for 20,000 strokes. Old Dutch Cleanser and Bon Ami removed approximately one-third millimeter of resin while the dentifrices produced changes ranging from .057 mm. for tooth paste D to .190 mm. for tooth powder A.

TABLE IV.

MATERIAL	SURFACE LOSS IN MM.*
Old Dutch	.338
Bon Ami	.320
Tooth Powder A	.190
Wernet's Dentu-Creme	.094
Tooth Powder B	.087
Tooth Powder C	.069
Tooth Paste D	.057

*Rotated brushing, 20,000 strokes.

Wernet's Dentu-Creme caused a loss of approximately .1 mm. Again the surface losses are closely correlated with both luster and weight changes. Only the most abrasive materials were used in this study as it could be assumed that all of the other cleansers would show less loss than tooth paste D.

It is considered clinically significant that the household cleansers will remove approximately one-third millimeter of resin when brushed for a period of time estimated to be equivalent to two years normal home cleansing. It is difficult to determine what the practical importance of such a surface change may be. How-

ever, it is logical to assume that when such care is exercised during the fabrication of the denture to minimize the very slightest change in dimensions, then this amount of surface loss is great enough to affect the adaptation of the base to the tissues. It must be remembered that the actual loss on a denture could be much greater than Table IV indicates. More frequent brushing for prolonged periods of time would greatly increase the surface loss. Also if each side of the denture loses one-third millimeter, then the total change between the tissue-bearing sides would be approximately two-thirds millimeter.

The smaller changes produced by most commercial denture cleansers and dentifrices may not be great enough to affect materially the adaptation of the denture. For example, tooth paste D caused a surface loss of only .057 mm., and it might be expected that the tissues would compensate for such a discrepancy.

Plastic Teeth.—

The use of plastic teeth in artificial dentures is becoming increasingly popular. Although the cleansers studied in this report do not have any effect on porcelain teeth, the more abrasive materials could possibly severely scratch plastic teeth. Therefore, a series of tests were made for studying the effect on this type of tooth. Only one commercial brand was used. Recent research has shown that teeth from the various manufacturers do not vary greatly in hardness, so results obtained on this particular tooth would probably be indicative of others.[16]

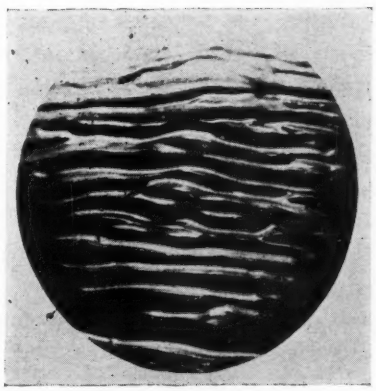

Fig. 21.—Plastic tooth after brushing with Bon Ami (×10).

Central incisor teeth were mounted so that brushing would be at right angles to the long axis of the tooth. The method of studying the effect was by visual and microscopic examination of the surface after brushing. Teeth were brushed with Bon Ami, Wernet's Dentu-Creme, and two tooth powders.

In all cases, severe scratching and grooving of the surface resulted. The appearance was similar to that obtained when the stationary denture base specimens had been brushed. A representative surface can be seen in Fig. 21. Thus the effect on acrylic teeth is apparently the same as that on the denture base itself, indicating that prolonged use of an abrasive cleanser could mar the tooth surface.

DISCUSSION

Only one resin was used in this study, as it was necessary to standardize this variable. Although denture base materials do vary slightly in their physical properties, it could be anticipated that most resins would be affected in a similar manner.

It may be argued that these tests are exaggerated and that the denture is not subjected to such vigorous or prolonged brushing. Results of the survey of denture patients, however, indicate that the 20,000 strokes equal approximately two years of home brushing. Many individuals in two years time may actually exceed this figure greatly if they resort to longer and more frequent brushings. Still another factor which must be considered is that in these tests the same solution was used throughout the brushing period. If a fresh solution were employed every few minutes, as is actually the case during home brushing, the abrasion might have been much greater. Undoubtedly some precipitation of the abrasive particles does occur during brushing and thus reduces the number of particles which can abrade the surface. Also many individuals will use thicker slurries or the dry powder alone which again would increase the abrasion. Thus, it was felt these figures represent minimum results which would be obtained clinically, and that the effects on the denture base might actually be much more severe with the use of methods commonly employed by the denture patient.

It is difficult to determine exactly how much weight and surface loss is permissible without seriously altering the dentures' appearance, fit, and cleanliness. Certainly the ideal cleanser would be one which would remove surface stain and debris without producing a change in the denture base. Probably any compound which does have cleansing power will also produce some surface change. However, it was not the purpose of this research to determine the best material, or even groups of materials, for cleansing artificial dentures; factors such as ability to remove stain and mouth odors would have to be considered. Such problems necessitate an entirely different study, and the object of this particular investigation was merely to evaluate the effect, if any, of the different agents that are commonly used.

It does appear from the data obtained that household cleansers are contraindicated due to the excessive abrasiveness which can remove appreciable amounts of the resin. As much as one-third millimeter of denture base may be removed after brushing for a period of time comparable to two years of normal brushing. Data also indicate that some dentifrice powders, after prolonged use, might have some deleterious effect. Most of the common proprietary compounds, whether used as immersion or brushing cleansers, have little or no effect.

SUMMARY

Cleanliness of the artificial denture is imperative in order to eliminate mouth odors, minimize tissue irritation, and maintain good oral tissue tone. Many types of materials are now employed for cleaning dentures.

The effect of various denture cleansers commonly used on acrylic resins was studied by means of weight and surface loss measurements, luster changes, and microscopic examinations of the surface. A mechanical brushing machine was

employed and a technique was developed for using rotating specimens. Preliminary to this study, a survey of denture patients was made at Indiana University School of Dentistry. The materials selected for this study and the brushing period employed were based on the results of this survey. The brushing period of 20,000 strokes was believed to be comparable to two years of normal brushing.

1. Immersion in proprietary compounds and in household bleaches has no effect on the resin, either by change in weight or color.
2. Brushing with household cleansers produced marked weight loss and the results obtained on the rotated specimens were approximately the same as those produced when the specimens were allowed to remain stationary.
3. The weight loss produced by the most abrasive dentifrice was less than one-half that caused by the household cleansers while only one proprietary compound induced any appreciable weight change. Miscellaneous agents such as salt, soda and soap had little or no effect.
4. A deep grooving action was produced by the more abrasive materials when the specimen remained stationary. With the rotated samples no deep scratches resulted. However, weight and surface loss measurements indicated a substantial amount of resin was being removed.
5. Surface loss with household cleansers reached a maximum of one-third millimeter.
6. Luster changes on rotated specimens correlated closely with data obtained in the other tests.

It is apparent from this study that household cleansers, and possibly some abraisive dentifrices, are contraindicated for routine use in cleaning artificial dentures. Prolonged use of such materials may affect the fit of the denture and make maintenance of a clean surface more difficult.

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A CRITICAL ANALYSIS OF MID-CENTURY IMPRESSION TECHNIQUES FOR FULL DENTURES

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EVEN a casual examination of the current dental literature will indicate the confusion that exists in the problem of impressions for complete dentures. Much of this confusion results from the fact that many impression procedures have been developed on an empirical basis. The individual abilities of the individual operators have led them to devise impression procedures which are particularly good in their own hands, but which others may be unable to handle successfully. Others have devised procedures which are best suited to certain materials which the manufacturers have urged them to use. Many have used the available knowledge of functional and histologic anatomy for the development of their impression procedures, but the variation in these techniques indicates a wide difference in the interpretation of the foundation for dentures. Still others have ignored anatomic limitations, and have devised techniques for impressions on a purely arbitrary basis. The great variation of methods, materials, objectives, and interpretation must leave the student of the problem with little but chaos in his mind as the result of his study.

CLASSIFICATION

There are far too many impression techniques to consider each one separately. Therefore, an attempt is made at classification on the basis of contemporary literature and observation of many impression procedures. Classification is difficult because of the overlapping of principles used in many techniques.

It is obvious that no single classification will suffice for all the many impression techniques in use today. Instead, three classifications are required. The first is based on the use of the actual anatomy of the individual patient or on arbitrary landmarks—anatomic or arbitrary; the second is based upon the mouth position while the impression is being built—open mouth or closed mouth; and the third is based upon the relative amount of pressure exerted on the tissues by the impression material at the time of the set—pressure, nonpressure, negative pressure, or selected pressure.

Any given impression technique can be placed in one or more of the above classifications. The exact designation cannot be made by a technique name or even the step-by-step description of the procedures. Only the individual dentist, with his own skills in the manipulation of the materials, and the knowledge of the possibilities and limitations, can determine the classification by which his technique can be designated.

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PRINCIPLES

There are certain principles upon which most authors agree regarding anatomic impressions. These principles are developed after considering the physical principles involved in the retention and support of dentures.

They agree that adhesion, cohesion, and atmospheric pressure are retentive forces. Adhesion is effective as the attraction of the saliva to the denture, and cohesion is effective as the attraction of the molecules of the saliva for each other. Close adaptation with the exclusion of air is essential to these forces. Atmospheric pressure is the pressure of the weight of the atmosphere on a surface. It is effective only with a peripheral seal, so it can be exerted only on the polished surface of the denture. It can be effective for short periods of time even though other physical forces are not effective. Capillary attraction or interfacial surface tension are forces which others claim to be the force which should retain dentures. It also requires absolute contact of the denture with the tissues. Mechanical locks or undercuts are assigned diminishing importance in retention of dentures. Gravity is of minor importance in the retention of lower dentures.

ANATOMIC IMPRESSIONS

Anatomy must be considered in two parts if it is to be understood in relation to impressions. Macroscopic anatomy is the study of the gross structure of the limiting and supporting structures, while microscopic anatomy is of importance in the study of the histologic structure of the supporting tissues.

Certain principles are recognized regarding the relation of gross anatomy. Dentures, i.e., impressions must cover the maximum amount of tissues within the limits of the health and function of the tissues. They must record the intimate detail of the surface of the soft tissues, and they must be built with a knowledge and understanding of the underlying gross structures, such as the shape of the bone and the attachment and direction of action of the muscles and other limiting structures.

Likewise, certain principles are recognized regarding the histologic structure of the supporting areas. Tissues, both bony and soft, respond to pressures. Soft tissues which are closely attached to bone are better able to support pressures than those with loose attachment. Thicker submucosal tissues may be displaced more than thin submucosal tissues. The anatomic impression techniques will be considered in relation to these principles.

Impressions, which have as their basis the anatomy of the mouth, vary with the (1) objectives of the operator, (2) the interpretation of the anatomy by the individual operator, (3) the variation which occurs in different cases, and (4) the materials and trays used.

OBJECTIVES

That the objectives of those who use anatomic impressions differ with the various authorities is obvious, when we consider their methods critically. Those who use an open mouth technique are attempting to record the limiting tissues in

their active state, while those who use a closed mouth technique are attempting to record these same limiting structures in a relaxed condition. The open mouth procedure is preferred by most of those who wish to record tissues with a minimum of pressure on the supporting structures, while most of those who use the closed mouth procedure wish to record tissues when a biting force is applied.

The open mouth impression is built in a tray which will carry the impression material of choice into the desired contact with the supporting tissues, and into an approximate relation to the peripheral tissues when the mouth is open and without applied pressure. The detailed record of these limiting tissues is imprinted into the final impression material by manipulation of these tissues by the operator or by the patient, or both. The rationale back of this method is that dentures do not dislodge when they are subjected to biting forces (except with occlusal disharmony and other mechanical errors). Dentures may be unseated when the tissues are pulled over the edges of the dentures, as in the function of speech, while the teeth are separated. The open mouth methods provide clearance for these tissues, and also for interferences between the ramus of the mandible and the upper denture when the jaw is in a protrusive or lateral position. The open mouth impression techniques develop a contour of the impression surface which is in harmony with the relaxed supporting tissues, and which may be out of perfect adaptation with these tissues when the denture is subjected to occlusal pressures.

The closed mouth impression is built in a tray with similar requirements to those for an open mouth impression. A more generous clearance is made for the various frenula so the patient can manipulate his tissues by closing, grimacing, sucking, and swallowing to form the peripheral borders. Also, occlusion rims are built on the tray so the patient can close against them as the impression is being formed. An alternate procedure is to use a central bearing point instead of the occlusion rims. The rationale behind the closed mouth impression technique is the thought that natural movements by the patient will conform the impression material to the anatomic limitations when the mouth is closed and under pressure. The pressure applied in closing the jaws on the impression material will displace the soft supporting tissues while the peripheries are being formed. The adaptation by this method develops more or less equalized pressure against the supporting bony foundation while biting forces are being exerted. The peripheral form of the impression does not allow the freedom of movement of some of the limiting structures that the open mouth procedures permit. The release of pressures of occlusion permits a rebound of the denture with a tendency for the peripheries to pull away from the mucosa which surrounds them.

UPPER ANATOMIC IMPRESSIONS

The variations in the interpretation of the anatomy of the mouth in relation to impressions for full dentures occur in both jaws.

There is basic agreement on the limiting structures of the upper jaw in most areas, but certain other areas and structures are handled differently. The anatomic impression procedures develop labial flanges which reach the relaxed mucous

membrane under the lip at the reflection. Provision is made for the labial frenum, and sufficient thickness is developed in the flange to support the upper lip for esthetics. There is a slight difference in the accommodation of the buccal frenum which has the caninus muscle attached just above it. The caninus muscle is a muscle of expression, and, as such, its action and direction of pull is affected by the action of the other muscles of expression. Some techniques call for this frenum to be pulled down into the softened impression material, while others have it manipulated forward and backward, thus providing more clearance for the frenum. The action of the muscles involved would indicate that the latter procedure is better.

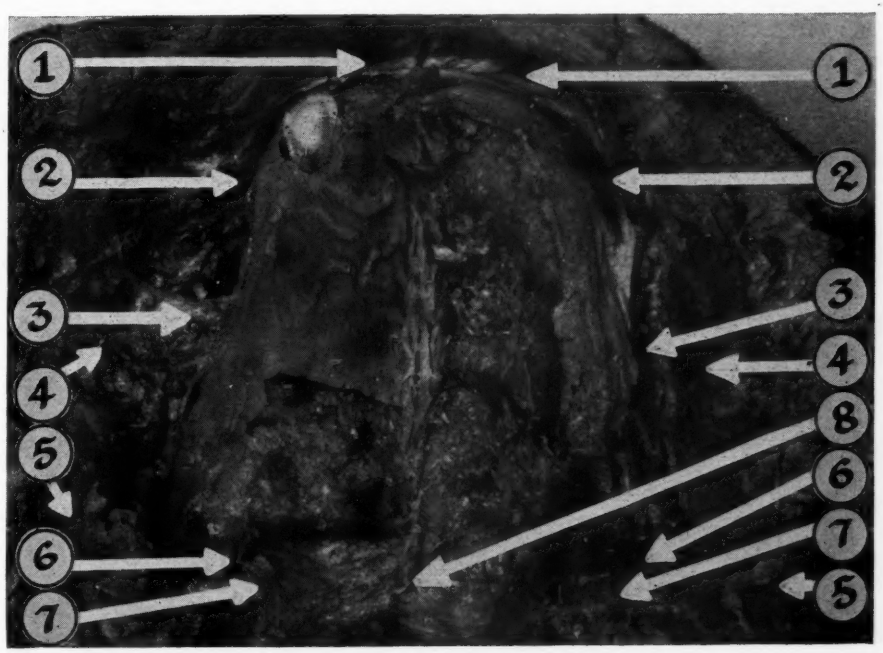

Fig. 1.—Limiting structures of the upper jaw. *1*, Labial mucous membrane reflection. *2*, Buccal frenum and caninus muscle. *3*, Buccal vestibule. *4*, Buccinator muscle. *5*, Ramus. *6*, Hamular notch. *7*, Pterygoid hamulus. *8*, Muscles of the soft palate back of vibrating line.

The space between the maxillary ridge and the cheek distal to the buccal frenum is called the buccal vestibule. Most anatomic techniques provide that this space be filled by the impression. The space must not be overfilled, but must allow for the normal function of the structures which surround the space. The buccal frenum may reduce the thickness of the flange anteriorly. The buccinator muscle whose fibers run anteroposteriorly in the cheek must not be forced laterally. The buccinator muscle turns in front of the masseter muscle and the anterior border of the ramus to attach to the pterygomandibular raphe distally. The anterior attachment is to the modiolus, the superior attachment is to the maxillary bone in the molar region, and the inferior attachment is to the buccal shelf on the body

of the mandible. Its action is to pull the corners of the mouth distally and to assist in the control of the placement of food on the teeth. The anterior border of the masseter muscle and the anterior border of the ramus will modify the position of the buccinator muscle and cheek in most cases. Some impression techniques do not make provision for this change of the size of the buccal vestibule during function.

The distal end of the upper impression must be distal to the maxillary tuberosity on the distal side of the hamular, or pterygomaxillary notch, and within the notch. There is a narrow cleft between the maxillary tuberosity and the pterygoid hamulus, which is filled with areolar tissue. This tissue is readily displaced by a post dam, provided the extra pressure is placed in the center of the notch. An excess extension to the distal at this point will impinge upon the hamulus which is the superior attachment of the pterygomandibular raphe. The raphe itself limits the distal extent of the impression when the mouth is open. Some techniques, particularly the closed mouth techniques, do not make adequate provision for the pterygomandibular raphe. Almost all agree that the impression must cover all of the maxillary tuberosity.

There is considerable disagreement regarding the distal limits of the palatal portion of the denture. Many use the "vibrating" line as the end of the denture. The vibrating line is the imaginary line which marks the beginning of the motion in the palate. This seems most logical since it uses all of the stationary tissues, and avoids the make and break contact which sometimes produces gagging. It also places the end of the denture in a favorable position for post damming. Any technique which does not extend the denture distally as far as the vibrating line is definitely inadequate. Some techniques extend the denture distal to the vibrating line, displacing the soft palate upward to develop the posterior seal. The disadvantage of this extension is that it interferes with the normal functions and movement of the soft palate.

SUPPORTING STRUCTURES

A study of the histologic structures of the soft tissues of the upper jaw reveals the relative ability of the various areas to withstand pressures. The crest of the upper ridge is covered with fibrous connective tissue, which is closely attached to the bone. It is the least displaceable of all the tissues, and best able to carry the stress of mastication. The tissues covering the rugae are also closely attached to bone and are able to resist anterior thrusts of the denture. The median suture where the two maxillary bones join together is covered with mucous membrane and very little submucosal tissue. The areas on either side of the midline, and medial to the alveolar ridges, are relatively soft and displaceable. It contains palatal glands and the blood and nerve supply to the posterior two-thirds of the palate, which enters the palate through the greater palatine foramen. The blood and nerve supply to the anterior one-third of the palate enters the jaw through the incisive canal which opens into the mouth under the incisive papilla. The tissue on the buccal and labial surfaces of the ridges is loosely attached except where the caninus muscle is attached.

The crest of the alveolar ridge is the primary stress-bearing area because of the type of tissue which covers it. The rugae area is the secondary stress-bearing area. The median suture should be relieved of pressure sufficiently to equalize the stresses applied there with those applied on the more resilient tissues covering the alveolar ridges. The incisive papilla should be relieved of pressure to protect the blood and nerve supply which emerges from the incisive foramen. The greater palatine foramen does not need relief because it is deep under palatal glands in a groove in the maxillary bone. The labial and buccal flanges must contact movable tissues in order to make a satisfactory valve seal area. The valve seal area across the distal end of the impression is developed by pressure of the post dam on mucosa which covers palatal glands which are readily displaceable.

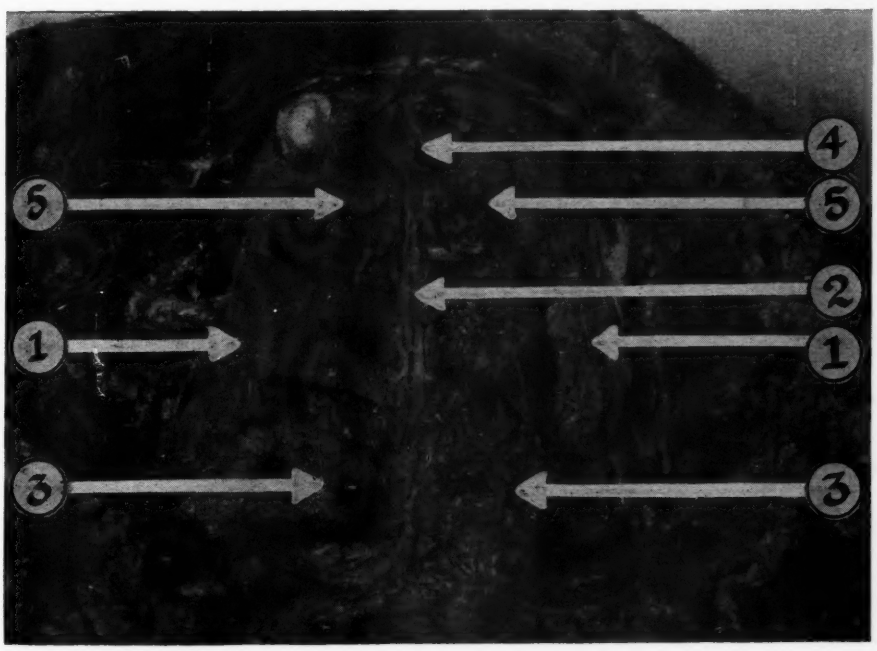

Fig. 2.—Supporting structures of the upper jaw. *1*, Fibrous connective tissue on the crest of the ridge. *2*, Median suture. *3*, Palatal glands and anterior palatine vessels and nerve. *4*, Incisive papilla and nasopalatine vessels and nerve. *5*, Rugae area.

There is considerable disagreement regarding the placing of pressures, relief, and post dams in upper impressions. Some impression techniques build additional pressure in the area least able to tolerate them—the median suture. These are the procedures which use a semiconfined plastic for the final impression. Some techniques are devised to produce the relief automatically by recording this area after the primary stress-bearing area has been recorded, and by displacing the tissues on the ridges while the impression is being made of the relief area. Some techniques record all tissue surfaces with a minimum of pressure and add mechanical relief to the cast. The method for this relief is not important. The important consideration is that relief must be made to equalize the pressure against the various areas of the palate.

Many ignore the relief of the pressure on the incisive papilla. This relief is absolutely essential because the incisive papilla is found on or near the crest of the alveolar ridge, and it is very soft. Any pressure upon it will interfere with the blood and nerve supply to the palate and may cause a burning sensation in the palate. This relief must be made mechanically.

There are many variations in the type and location of the post dams. Some techniques place the post dam in the tray and displace the tissues at the time of the final impression. Others carve the post dam in the cast after the final impression. Others do both. The post dam should pass through the hamular notch on either side and follow along the vibrating line across the palate. It should vary in thickness with the thickness of the underlying soft tissues. The width of the post dam should not exceed 4 millimeters. The practice of adding pressures anteriorly on either side of the relief area is not sound. It adds pressure unnecessarily over the blood and nerve supply to the posterior part of the palate. An acceptable practice is a reasonable post dam in the final impression and a small groove 1 mm. deep and 1 mm. wide, carved on the cast about 2 mm. in front of the vibrating line. The carving of a deeper post dam at the distal end of the denture is not sound because it displaces too much tissue causing irritation to the palate and a displacing force to the denture. Some techniques call for a small groove not to exceed 0.5 mm. in width or depth to be cut in the cast around the impression of the labial frenum. This is helpful because this is often the weakest part of the peripheral seal.

LOWER ANATOMIC IMPRESSIONS

There are more differences in the anatomy of the lower jaw than in the upper. Even though there is basic agreement as to the theoretical extent of lower impressions, the amount of extension in certain areas varies greatly in different techniques.

There is agreement that the labial flange should be extended to contact the mucous membrane reflection at rest, with adequate clearance for the lower labial frenum. The thickness of this flange should be sufficient to restore the proper esthetic position of the lower lip.

The lower buccal frenum marks the anterior end of the buccal vestibule and the posterior limit of the labial vestibule. The lower buccal frenum is a fold of mucous membrane which attaches the cheek to the ridge. The triangularis muscle, which is a muscle of expression, attaches to the mandible just below the frenum. The action of this muscle varies with the action of the other muscles of expression. Clearance for the buccal frenum must be made distally as well as upward in the flange in order to prevent dislodgment of the denture.

The buccinator muscle lines the cheek with its fibers coursing anteroposteriorly. Its inferior attachment is in the buccal shelf on the body of the mandible. The buccal shelf is the space between the crest of the ridge and the external oblique line. The buccal shelf of the mandible is covered with cortical bone which is ideal for carrying the stresses of occlusion. Some techniques provide that dentures should stop short of all muscle attachments. This does not agree with those

which are designed to have the buccal shelf carry the heavier stresses of occlusion. Also, they do not develop adequate contact with the soft tissues of the cheek. These techniques do not use the maximum tissue coverage within the limits of the health and function of the tissues. The horizontal direction of the fibers of the buccinator makes extension of dentures over this area possible.

A factor which has been overlooked in many techniques is the suctorial pad in the cheek. This fatty pad lies medial to the buccinator. The buccal flange of the impression can be developed so this pad will fold over it to assist in perfecting the peripheral seal.

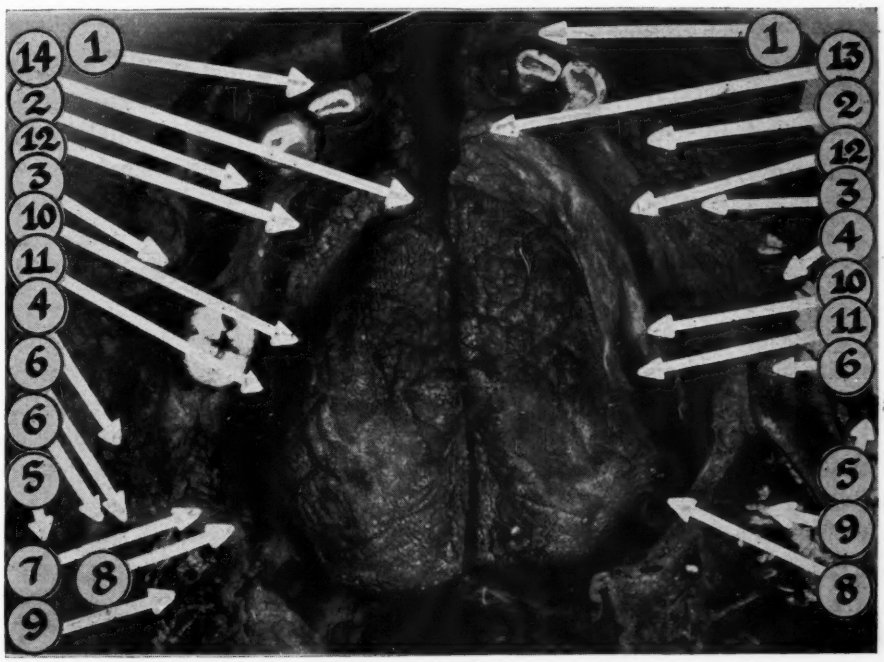

Fig. 3.—Limiting structures of the lower jaw. *1*, Labial mucous membrane reflection. *2*, Lower buccal frenum and triangularis muscle. *3*, Buccal vestibule and buccinator muscle. *4*, Buccinator muscle. *5*, Masseter muscle. *6*, Anterior border of the ramus and temporal tendon. *7*, Pterygomandibular raphe. *8*, Superior constrictor of the pharynx. *9*, Internal pterygoid muscle. *10*, Alveololingual sulcus. *11*, Mylohyoid muscle. *12*, Premylohyoid depression. *13*, Floor of the mouth and anterior portion of the alveololingual sulcus.

The buccinator muscle turns in front of, and medial to the anterior border of the masseter muscle, the anterior border of the ramus, and the temporal tendon to attach to the pterygomandibular raphe and into the retromolar pad.

The masseter muscle presses the buccinator muscle inward against the buccal flange of the lower denture at its distobuccal angle, when it is contracted. Provision for this action should be made in the impression procedure.

The anterior border of the ramus and the temporal tendon are static limiting structures at the distal end of the lower impression. Most all techniques cover the retromolar pad and thus make sufficient contact with these structures. Im-

pressions cannot be locked against the ramus in this area as has been suggested, because the buccinator muscle crosses between the bone and the impression. The muscle must be allowed freedom of action.

THE LINGUAL FLANGE

The pterygomandibular raphe extends from the pterygoid hamulus to the top, distal, medial angle of the retromolar pad. It may be observed as a band of tissue connecting the upper and lower jaws, when the mouth is open wide. It provides a definite limit to the impression in this area. Closed mouth techniques do not register this structure adequately.

The superior constrictor of the pharynx crosses from the lingual to attach to the mandible just below the point of attachment of the pterygomandibular raphe to the retromolar pad. Its fibers make up part of the pad. This muscle and the mucous membrane covering it, and that supported by it (the retromylohyoid curtain) provide the limiting factors for the distal extent of the lingual flange. Its position will vary with the position of the tongue.

The internal pterygoid muscle is immediately distal to these structures, and will displace them anteriorly if the lingual flange is too long distally and closing forces are exerted.

The length and conformation of the lingual flange of the lower denture has been the subject of much controversy. Some say the impression should stop well short of the space at the distal end of the alveololingual sulcus. The claim is made that it adds nothing to the retention or stability of the denture. Others, who seem to have the better interpretation, assign three purposes to the extent of the impression into this area: (1), it is extended to assure a complete peripheral contact with the tissues in all tongue positions; (2), it is developed to guide the tongue to a position on top of the lingual flange of the denture, and (3), it prevents the tongue from feeling space between the lingual flange and the lower ridge in the molar region.

The entire lingual flange rests in the alveololingual sulcus which is the space between the alveolar ridge and the tongue. The mucous membrane floor of the mouth covers the mylohyoid muscle and sublingual gland, and forms the bottom of the sulcus. The retromylohyoid curtain is the distal end of the alveololingual sulcus. The mylohyoid muscle is a broad flat muscle which has its origin on the body of the mandible. Its attachment extends anteriorly to the midline of the mandible and posteriorly about 1 cm. distal to the end of the mylohyoid ridge, to which it attaches also. Its insertion anteriorly is to its fellow of the opposite side, and posteriorly is to the anterior part of the hyoid bone. Its function is to raise the floor of the mouth and the hyoid bone which it supports. When it is relaxed, it curves downward and inward; when it is contracted, it straightens out on a direct line between its origin and insertion.

The inclination of this muscle is of importance in the region distal to the anterior end of the mylohyoid line, as it changes the shape of the alveololingual sulcus in its various degrees of contraction in this area.

Many interpretations are placed on the possible use of the anatomy of the alveololingual sulcus in the molar region. Some techniques prescribe that the lingual flange of the denture should end at the mylohyoid ridge in order to avoid interference with the action of the mylohyoid muscle. These techniques ignore the basic principle that all denture borders should end in movable tissues. Others describe the lingual flange as stopping 2 mm. below the mylohyoid line. These have the same disadvantage. Others cause the lingual flange to be extended below the mylohyoid ridge to contact the floor of the mouth, but allow it to extend under the mylohyoid ridge. These do interfere with the action of the muscle and of the tongue.

The lingual flange of the lower impression can be extended below the mylohyoid line and in contact with the floor of the mouth provided the flange in the molar region is developed to slope toward the tongue. The amount of this extension will vary with the anatomy of the individual patient and with the direction of the slope of the flange. The more nearly horizontal the flange is constructed, the further it may be extended, within limits.

A lingual flange which is properly sloping toward the tongue develops a space between itself and the soft tissues covering the lingual surface of the mandible. This space disappears when the mylohyoid muscle is contracted, or when the tongue is in function toward the opposite side or in protrusion. The edge of this flange makes a continual contact with the soft tissues in the floor of the mouth which prevents these tissues from being pinched under the denture. The edge of the lingual flange maintains its contact back to the retromylohyoid curtain and up to the occlusal surface of the distal end of the impression. The distal end of the lingual is developed so as to curve away from the tongue, and toward the mandible. Its purpose is to guide the tongue to rest on top of the lingual flange, and thus avoid displacement by the tongue.

The distal end of the lingual flange cannot be locked against the bone as is suggested by some techniques, because this part of the impression covers the distal end of the attachment of the mylohyoid muscle.

The area just anterior to the anterior end of the mylohyoid line is also subject to differences of interpretation. The mylohyoid muscle in this area curves downward and inward to meet its fellow of the opposite side. Its contraction may change the level of the floor of the mouth in considerable amounts. The lingual surface of the mandible in this area (the bicuspid area) is relatively thinly covered by soft tissues which are rather loosely attached to the bone. These loosely attached tissues do not tolerate pressures well. The techniques which describe a "rest" between this area and the anterior border of the ramus diagonally across the mouth are not on a firm anatomic foundation. Stability of lower impressions must come from the maximum use of all bony foundations where the tissues are firmly and closely attached to bone. The flange should be sufficiently long in this area to make a maximum contact with the floor of the mouth without causing injury to the tissues. The flange should have perfect adaptation to the lingual slope of the ridge to these limits.

The use of the area of the alveololingual sulcus from cuspid to cuspid also varies with different techniques. Some design the flange short to correspond to the highest position of the floor of the mouth making provision only for the lingual frenum. A compromise at the midlevel height of the floor of the mouth seems most logical. It allows for normal tongue action, but may prevent extreme protrusion of the tongue which is not necessary.

The thickness of the lingual flange has been increased arbitrarily in some of the more recent techniques. While there may be some advantage in this procedure in some cases, there are also some disadvantages. The tongue action is limited slightly, but, more important, these thick flanges may interfere with the openings of the submaxillary ducts. Occlusion of the submaxillary caruncles by the lingual flange may prevent the free flow of saliva from the sublingual glands. Also, it has been observed that the flow of saliva under the thick lingual flange will build up a deposit of calculus on the denture which may even extend into the alveolar groove covering the ridge itself.

A study of the various techniques for lower impressions reveals that too little thought has been given to the histologic structure of the soft tissues covered by the impression, and to the structure and conformation of the bone which supports the denture. Impression outline form and the use of materials seems to have been the major consideration.

SUPPORTING STRUCTURES

The same fundamental principles regarding the behavior and reaction of tissues under stress apply to lower impressions as well as to upper impressions.

Tissues which are tightly attached to bone are better able to carry the stresses than those which are loosely attached. They also have a greater tendency toward keratinization. Tissues which are thicker are more readily displaced than those which are thin, and are less subject to damage by pressure.

The total area covered by the lower impression can be divided into areas of primary function. The entire periphery of the impression must end in soft tissues. This valve seal area includes the retromolar pad. The retromolar pad is a triangular soft pad of tissue at the distal end of the lower ridge. It is made up of fibers of the buccinator muscle, the temporal tendon, the pterygomandibular raphe, the superior constrictor of the pharynx and palatal glands. It is quite soft and cannot be considered a stress-bearing area. Some techniques place a post dam on this pad, but this is not sound because of the nature of the structures which make up the pad. All of the pad should be covered by the impression with a positive contact, but with no extra pressures.

The primary stress-bearing area in most impression techniques is the crest of the alveolar ridge. Fibrous connective tissue which is closely attached to the bone covers this area. However, the structure of the underlying bone in this area may be unfavorable for carrying stresses. It may be sharp, or cancelous, or have large nutrient canals. Therefore, it has been suggested that the primary stress-bearing areas should be the buccal shelf on each side and the slopes of the ridge. The buccal shelf is covered with good cortical bone and is smooth and

nearly horizontal. The crest of the ridge then becomes the secondary stress-bearing area. The buccal shelf is covered by movable tissues which are loosely attached to the bone. The buccinator muscle attaches to the buccal shelf, but the direction of its fibers is horizontal and cannot affect the denture or be affected by it. Areolar and fat tissues make up the remainder of the thickness of the covering of the bone in this area. Since this tissue is thicker than that which covers the crest of the ridge, a technique which would place slightly more pressure on the buccal shelf than on the crest of the ridge would seem to be indicated. On the basis of this analysis the area of relief would be the mylohyoid ridge.

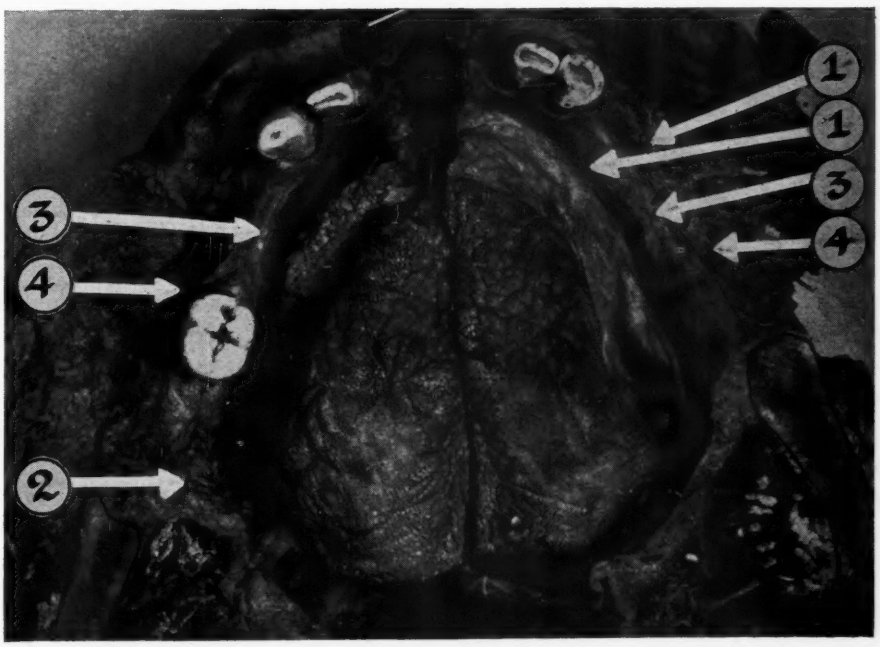

Fig. 4.—Supporting structures of the lower jaw. *1*, Slopes of the ridge. *2*, Retromolar pad. *3*, Fibrous connective tissue covering the crest of the ridge. *4*, Buccal shelf.

INDIVIDUAL VARIATIONS

It becomes increasingly obvious that there is too much reliance upon step-by-step techniques, and not enough variation in techniques to meet the specific requirements of individual cases. Any technique is a tool in the hands of the operator. It is the responsibility of the dentist to choose the proper technique to meet the requirements of each patient. Just as the physician chooses from a wide array of drugs, we must choose from a wide array of techniques. It is our duty to know exactly what each procedure does, and choose or combine procedures to develop a technique for each patient which will produce the best results for that patient.

There are several conditions found in upper jaws which indicate variation from standard procedures regardless of the routine technique we may prefer.

Hyperplastic ridge areas require different treatment than normal healthy ridges. It is necessary to remove the hyperplastic tissue or to control it. It can be controlled by making space for it in the tray in a position directly under its bony foundation. It should not be allowed to bend forward from this position. It should not be subjected to pressure during the final impression or it will tend to cause a rebound of the denture when it is finished.

A torus palatinus must be relieved mechanically in addition to any relief which may be made for it in the impression.

Large nutrient canals in the alveolar ridge may be diagnosed by roentgenogram. Pressure on these canals must be avoided by placing heavier pressures in other areas.

The lower jaw presents even more variations than the upper. Hyperplastic ridge areas may be controlled in the same manner as in the upper jaw. Cordlike lower ridges must be likewise be recorded with pressure on the slopes of the ridge rather than on the crest. Sharp or spiny ridges must be relieved. Pressures must be avoided on areas with large nutrient canals. Pressures may be avoided on the mental vessels and nerve by allowing more thickness of a soft impression material in this area than in other areas, or by making the impression softer in this area than in others. The torus mandibularis can be relieved in a similar manner. There are many other specific situations or conditions which require special handling of impressions for both the upper and the lower jaw. The best method should be chosen for each case on the basis of the anatomic and physiologic requirements of the case. This procedure should be modified as indicated by the special problems involved in that case. No one technique nor material will meet the needs of all cases.

Added pressure may be developed in a given area in a number of ways. The use of a more resistant material will develop more pressure than a soft material. The relief of some areas in the tray without relieving other areas will develop more pressure in the areas which are not relieved if the final impression is taken under some pressure. The substitution of a soft material for parts of a finished impression will relieve those areas and place additional pressures on the areas not so treated. The addition of impression wax to certain areas of a finished impression will place additional pressures in those areas. Judgement and knowledge and experience will indicate the need for these modifications of impressions based on the anatomy of the mouth.

IMPRESSION MATERIALS

The materials used for impressions vary widely in themselves, and their behavior varies with their manipulation. There are several classes of materials in common use today. These include modeling compound, plaster of Paris, impression wax, zinc oxide and eugenol paste, alginates, and activated resins. These materials prepared by different manufacturers have modifications which produce certain working characteristics. These variations are desirable in order to achieve the requirements of the objectives and meet the abilities of the individual operators.

Modeling compound is an excellent impression material when it is properly handled. It has a wide range of uses since it is varied by its composition to have different fusing points. It may be used for trays if it is high fusing, or it may be used as a final impression or as a part of a final impression if it is medium or low fusing.

Modeling compound must always be used in a rigid tray which is not affected by heat if it is to produce a satisfactory final impression. The tray must be oversize in relation to the supporting tissues and slightly short of the reflecting tissues if it is to produce an adequate peripheral outline to conform to the anatomy of the mouth. The edges of the tray must not be more than 3 mm. short of the reflections.

Modeling compound can be softened uniformly in wet heat for over-all adaptation, or it can be softened in small areas by dry heat for localized modifications. Its plasticity is increased by higher temperatures in relation to its normal fusing point. It must be heated sufficiently to allow it to flow readily under a minimum of pressure because by its nature it flows sluggishly. If it is not heated sufficiently to be thoroughly soft, it has a tendency to "bridge." When it is heated in a tray and inserted in the mouth under pressure it is a semiconfined plastic. As such, it exerts its greatest pressure in the center of its mass. Thus, the maximum pressure against the upper jaw would be exerted at the center of the palate, rather than on the ridges. The greatest pressure on the lower jaw would be exerted on the crest of the ridge. However, it is possible to regulate the order of heating various areas of compound to regulate the amount of pressure applied to each area by the finished denture. It is used by many of those who use closed mouth impression procedures.

Plaster of Paris and the modified forms of plaster of Paris are the most commonly used impression materials. Their manipulation is simple and not time consuming after the tray is constructed. The consistency and setting time is readily controlled by the operator by changing the proportions of plaster and water used, or by varying the temperature of the plaster of Paris.

Plaster of Paris flows readily with a minimum of pressure when it is mixed to a creamy consistency. It will not displace soft tissues as much as modeling compound, and will record detail with more accuracy. It will produce an impression with a more uniform tissue contact than either modeling compound or wax because of its plasticity before set.

Plaster of Paris sets by chemical action and is not correctable. Some operators attempt correction by the addition of wax in the defective areas, but this cannot be done satisfactorily. Plaster of Paris causes dehydration of the tissues during its "set" which causes it to cling tightly to the palate even though it may be defective. Dehydration may be advantageous in upper impressions by absorbing the mucous secretions which occur during the set. It is not as efficient for lower impressions as for uppers in mouths of patients with copious saliva because of its tendency to wash away.

Trays for plaster impressions have very positive requirements. Stock trays are inadequate because this material must be supported very closely to the tissue

it is to record. An individual tray is essential. It must be rigid and made to conform to the contours of the mouth, but with clearance for the final impression material. Trays may be made of modeling compound, shellac base plates, or other materials which can be modified easily. The flanges of the tray must reach within 1.5 to 2 mm. of the reflections. The tray must be post dammed because of the need for additional pressure for a seal at the posterior end of the denture. The post dam should not be on top of the plaster wash. The entire inside of the tray, except the post dam, should be oversize to allow the material to flow freely and to avoid "pressure points" where the tray contacts the tissues. Some operators do not relieve the tray at all before taking the plaster wash. They are producing more pressure than is desirable inside the denture, and are not recording the detail of the tissue surfaces with the accuracy that is possible with this material.

Most plaster wash impressions are open mouth impressions, but plaster wash impressions may be built in modeling compound trays by the closed mouth method. When this is done the tray is relieved in all areas except the post dam and the crest of the ridge which is to carry the stress of closure. The central bearing point is used for pressure by the patient, while they are molding the peripheral form of the flanges.

WAX

Impression waxes are used by some as the final impression material. Waxes are available with specific melting points which vary with the composition of the wax. The choice of the wax for each type of impression is important. Normally the wax chosen for the base lining of the tray softens slightly below mouth temperature. Waxes with higher fusing points may be chosen for developing additional pressure in certain areas. Waxes are used for correction of other impressions and for post damming other impressions.

The trays used for wax impressions must be most accurately formed. Wax can be molded by the tissues, but it must be adequately supported in relation to the limiting tissues or it will be distorted when the impression is removed from the mouth, even though it is chilled. Waxes are plastics, and, as such, will develop the greatest pressure in the center of the mass of wax in the impression. Technical procedures must be devised which will counteract this, or the greatest pressure will be in the center of the upper impression, or on the crest of the lower ridge. This can be done by judicious relief of the tray, and by modifying the sequence of the application of the wax. The material is kind to the tissues and lends itself well to the closed mouth techniques. Impressions in wax are correctable by the addition of more wax and reinsertion.

Most operators who use wax build an excellently adapted modeling compound tray and develop the final impression in this tray. Some relieve the tray, and others do not. Relief in the tray seems desirable. Wax needs time and the heat of the mouth for fine adaptations to tissues. Insufficient time in the mouth will cause bridging and excess pressures in certain areas. Clearance is desirable

to ease the flow of the material. Wax has a tendency to displace tissues, and may not record surface detail as well as other materials, if it is not properly handled. Its ease of distortion, both in removal from the mouth and in subsequent operations, make it a difficult material to handle properly. It is a good material when it is used correctly.

ZINC OXIDE AND EUGENOL

The zinc oxide and eugenol pastes are used by many for final impressions. These impression pastes or creams are gaining in popularity because of their ease of manipulation, their accurate surface detail, their ease of flow, and their quickness of set. They do not work as well for some upper impressions as plaster of Paris because the material is displaced by mucous secretions. They do work well for lower impressions because they are not washed away by saliva. They are not correctable in deficient areas in spite of some manufacturers' claims, but may be corrected with wax. Those which set "hard" are better than those which may "bend" when set. These materials are used most frequently in open mouth impression techniques. Their easy flow allows them to be seated with a minimum of pressure. Biting forces would displace too much of the material and cause pressure points where the tray would show through the material. They are used in both the anatomic and arbitrary impression techniques.

The formation of the tray is the most important phase of the anatomic impression techniques which use the zinc oxide and eugenol pastes. The tray must be oversize in relation to the supporting structures in the mouth so that no portion of the tray will contact the tissues except where additional pressures are desired. In these areas, it is imperative that the tray be formed with great care and with accuracy.

The ease of flow, which makes possible the recording of fine detail with a minimum of pressure, makes its control at the peripheries difficult. This can be accomplished, however, by developing an accurate rim on the tray which conforms to the anatomic limitations. Modeling compound added to the flanges of the individual oversized trays, and properly muscle trimmed, will support this material against the limiting tissues. A post dam of modeling compound will adequately control the material posteriorly for upper impressions.

ALGINATES

The alginates or irreversible hydrocolloids are comparatively new for use as an impression material for full dentures. Their ease of manipulation and of flow suggest their possibility for recording tissue surfaces with a minimum of pressures. They are applicable only in open mouth techniques.

Trays for alginate impressions have rigid requirements. They must be oversize to avoid contact with the supporting structures; they must conform to the limiting anatomic structures, and yet be short of them; they must confine the material sufficiently to insure contact with the tissues, and they must have a mechanical lock to hold the material in the tray.

The trays must be individual, but they may be made of modeling compound. Shellac bases or activated resins may be used if modeling compound is added to the flanges and muscle trimmed, then cut 2 mm. short of the reflections.

The difficulties in using this material are to hold the impression in the tray, and to remove the impression from the mouth.

A number of methods have been used for the retention of the impression in the tray. Holes may be drilled in the tray, or the surface of the compound on the tray, or the tray may be painted with alcohol and cotton fibers attached to it. The tray must be dry when the alginate material is placed in it. The tray and impression can be removed from the mouth if dental floss is threaded through two holes in the tray before insertion into the mouth. The impression is removed by pulling on the dental floss.

These impressions record good detail of tissue surfaces with a minimum of tissue displacement. The accuracy of the impression will depend upon the accuracy of the tray. Care must be used in the preparation of the material and in its handling after removal from the mouth. It is easily distorted, and it loses moisture and shrinks if it is allowed to dry out before the cast is poured. Further observation and tests are necessary before this material can be correctly evaluated.

ACTIVATED RESINS

Certain activated resins are used for impression materials. These resins are quite resistant to flow and cause tissue displacement. They depend upon the softening of the surface of the impression by solvents in order to record detail. The activated resins produce excess pressure in the center of the palate and on the crest of the lower ridge. Tissues are displaced by this material (the manufacturer says "smoothed out"). It has the further disadvantage of being subject to shrinkage both during and after the impression is formed.

An oversized tray is used for the activated resin impression material, but the suggested tray does not adequately control the peripheral form to the anatomic limitations.

ARBITRARY IMPRESSIONS

The arbitrary impression techniques are not new. They are variations from sound procedures devised for the purpose of promotion of the financial welfare of the individual who claims originality, or the laboratory which claims that it is the only one that can do the remaining operations correctly, or the manufacturer who has a material to sell. The parts of these techniques which are sound have their basis on the work of those who preceded them. The principles which are claimed for these techniques have been well established long before the techniques were devised. Some of these techniques are devised by lay persons without proper background in the fundamentals of anatomy and physiology or even the mechanical factors involved.

Included in this class of impressions are those which require a special kind of tray which is for sale by the sponsor only if you take his course. The purpose

of a tray is to carry and confine the impression material. Dentists know how to build trays to meet their needs, and the materials are available, but the sponsor of the technique insists that the dentists pay him to teach the dentist what he already knows. This would not be too serious except that the principles of the technique are founded on half truths and misapplication of truths. Only a part of the available foundation for dentures is used, and the proper support of the lip for esthetics is impossible because of the knife-edge flanges. Atmospheric pressure is ruled out as a retentive factor. All failures are attributed to factors other than the impression.

Another arbitrary impression technique devised by a dentist from the work of other dentists is sold to dentists by a laboratory. The peripheral outline of the denture is not determined by the dentist, but is determined by the technician in the laboratory on the basis of lines drawn on the cast. There is no consideration of individual characteristics of the patient's mouth, but rather a predetermined, arbitrary outline is formed. This outline, incidentally, ends the lower lingual flange at the mylohyoid ridge. Dentists must patronize this particular laboratory in order to obtain the 'benefits' of this technique for their patients. It has the franchise on the technique.

A manufacturer of dental materials developed an impression material, and in order to sell the material, a technique was devised for its use. By a strange coincidence, the technique and the material had the same name. This technique was supposedly based upon the anatomy of the mouth. But an examination of the illustrations of the mouth anatomy in publications by the manufacturer reveals that the anatomy has not been correctly illustrated. Further, the technique calls for certain arbitrary lines to be drawn on casts from one specified landmark to another without making adequate allowances for individual variations. It is another attempt to make routine an operation which can never be routine for the best results.

These and other arbitrary impression techniques are an insult to the intelligence, education, and training of dentists. Those who are misled by the sales talks of the promoters are not fulfilling their obligation to their patients.

SUMMARY

Impression techniques in use at the middle of the twentieth century vary not only in the plan of the technique, but with the use of the plan by each operator as well. Evaluation can be made only by an analysis of the resultant impression, area by area, in relation to the part of the mouth to which that part of the impression is adapted. The supporting structures have equal importance with the limiting structures in this analysis. The value of the procedures used will depend upon the recognition of possibilities and limitations of anatomic form and structure of the mouth, and the characteristics of the impression materials selected. Arbitrary impression techniques do not meet the requirements of an impression technique.

CONCLUSION

The means employed in building an impression is of relatively little importance, except in regard to the impression problem of any individual. There is no single ('best') impression technique. The variety of impression materials, and the range of working characteristics of these materials, make possible the development of impression procedures best suited for the specific conditions in each area in a given mouth. Blindly following a technique will not produce the results which are possible by critical analysis of the requirements of the patient and, therefore, devising a technique for that particular patient. A technique should be an orderly sequence, but not a dictator. The test for any impression—does it do what it should do in every area?

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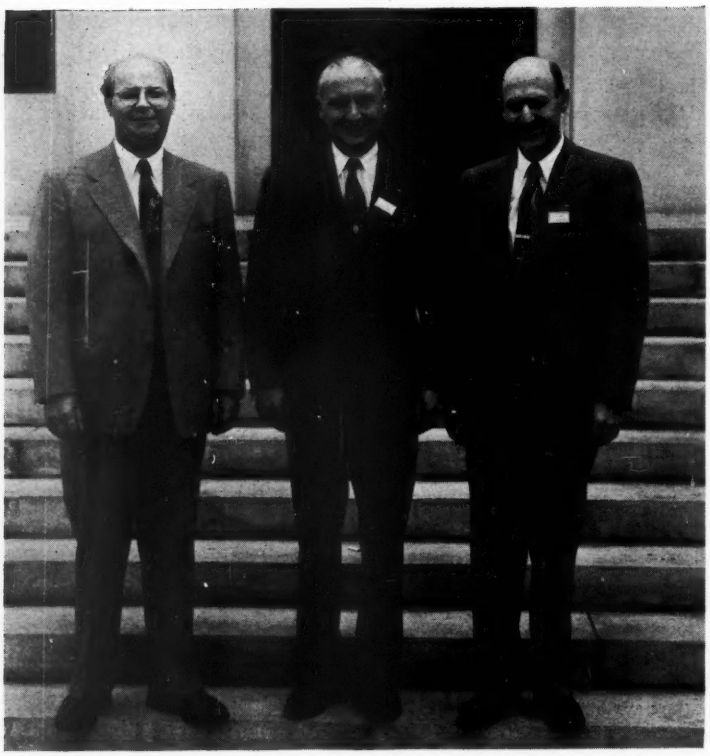

Dr. Roland D. Fisher, President of the Pacific Coast Society of Prosthodontists, Dr. Harold L. Harris, President of the American Denture Society, and Dr. Carl O. Boucher, President of the Academy of Denture Prosthetics, together on the occasion of the meeting of the Academy of Denture Prosthetics at the National Naval Medical Center, Bethesda, Md., May 4, 1951.